DOCUMENT RESUME

ED 189 193 TM 800 376

TITLE ACER Chemistry Test Item Collection. ACER Chemtic Year 12.
INSTITUTION Australian Council for Educational Research, Hawthorn.
PUB DATE 80
NOTE 64p.
AVAILABLE FROM Australian Council for Educational Research Limited, PO Box 210, Hawthorn, Victoria, Australia 3122 ($11.50)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Achievement Tests: Atomic Structure: Chemical Analysis: Chemical Bonding: Chemical Equilibrium: Chemical Nomenclature: Chemical Reactions: *Chemistry: Diagnostic Tests: Foreign Countries: *Grade 12: High Schools: *Item Banks: Multiple Choice Tests
IDENTIFIERS ACER Chemistry Test Item Collection Year 12: *Australia

ABSTRACT

The chemistry test item banks contains 225 multiple-choice questions suitable for diagnostic and achievement testing: a three-page teacher's guide: answer key with item facilities: an answer sheet: and a 45-item sample achievement test. Although written for the new grade 12 chemistry course in Victoria, Australia, the items are widely applicable. Items are grouped in six course units and cover these topics: the nuclear atom: electronic structure: periodic table: mole and chemical formulae: chemical reactions: stoichiometric calculations: chemical equilibrium: transformation and production of energy by chemical reaction: chemical reactions driven by electrical energy: carbon and silicon (elements, hydrides, covalent bonding, oxides): oil and coal derivatives: polymers: molecules of biological importance: nitrogen and phosphorus (elements, oxides, role in living systems): ammonia and phosphine: oxygen, sulfur, and metals (elements, commercial sources): direct formation of oxides from metals: oxides of sulfur: sulfuric acid: water and hydrogen peroxide. (Author/CP)

ACER CHEMTIC
YEAR 12

ACER CHEMISTRY TEST ITEM COLLECTION

AUSTRALIAN COUNCIL FOR EDUCATIONAL RESEARCH

Published by
The Australian Council for Educational Research Limited
Frederick Street, Hawthorn, Victoria 3122
February 1980

Typeset by Monotrade Pty Ltd
68 York Street, South Melbourne, Victoria 3205
Printed and bound by
Allanby Press Printers Pty Limited
1a Crescent Road, Camberwell, Victoria 3124

ACER Chemistry Test Item Collection (ACER CHEMTIC YEAR 12)

Contents

The Australian Council for Educational Research Limited, Radford House, Frederick Street, Hawthorn, Vic. 3122 — ACER CHEMTIC YEAR 12.

Acknowledgments

Several chemistry teachers contributed outstandingly to the production and editing of items. Particular thanks are due to the following teachers, all of whom contributed many items, and were active participants at review panels.

Mr E. Clarke	Syndal High School
Dr C. Commons	Camberwell High School
Mr R. Fox	Carey Baptist Grammar School, Kew
Mr R. Stokes	Elwood High School

Other teachers who contributed to this collection were

Mr W. Facey	Rosebud High School
Mrs K. Mullins-Gunst	Academy of Mary Immaculate, Fitzroy
Mr D. Hyatt	Curriculum and Research Branch, Education Department, Victoria
Mr D. Jenkins	Orbost High School
Mr B. Kelly	Swan Hill High School
Mr P. Kendall	St Joseph's Regional College, Echuca
Ms A. Meehan	Upfield High School
Mr J. Neal	Haileybury College, Springvale
Dr R. Ross	Eltham College, Research
Mr B. White	Derrinallum High School
Mr D. Williams	State College of Victoria, Melbourne

The development of the collection was aided during the trial testing of the items by the co-operation, with ACER, of teachers and students from 50 secondary schools.

Introduction

This collection of chemistry items is a publication enabling Victorian chemistry teachers to have access to a range of items suitable for diagnostic and achievement purposes pending the publication of a larger chemistry item bank. This publication contains 225 items relevant to the core syllabus for Year 12 chemistry as published by VISE for 1980.

It is hoped that teachers will produce additional items of their own for this collection, and some notes on test construction and item writing techniques are included later. Although all the items in this publication are of the multiple choice form, teachers should feel free to include extended response type items as well as additional multiple choice items. The ACER would be grateful if individual teachers forwarded on to the Council their own *original* items. Suitable items will be added to the chemistry item bank at a later date. Items should be forwarded to:

ACER Chemistry Item Bank,
PO Box 210,
Hawthorn,
Victoria 3122.

The chemistry item bank project

During 1978 the VUSEB Chemistry Standing Committee suggested that the new Victorian Year 12 course would be assisted by the provision of a collection of test items. Later in 1978, the Victorian Education Department (Secondary Division) agreed to second a practising chemistry teacher to ACER to work on the preparation of a bank of chemistry items, related not only to the Victorian course, but to chemistry courses in each of the other States. Initially it was agreed to publish a collection of items for use in Victoria only, during 1980 and 1981, pending the completion of the item bank. The project was placed under the direction of a committee of management comprising:

Dr J. P. Keeves and Dr J. F. Izard representing the ACER,

Mr M. Cropley representing the Victorian Institute of Secondary Education,

Mr R. Fox representing the VISE Chemistry Subject Committee, and

Dr I. Wilson representing the Chemistry Education Association.

Mr Peter Martin was the secondee responsible for the day-to-day management of the project during 1979.

Most of the items included in the initial publication were written by practising chemistry teachers, although a few items were culled from the ACER Diagnostic Chemistry Tests 'M' Series (out of print). After an initial editing, items were reviewed by a panel comprising practising chemistry teachers and specialists in educational measurement. These reviewing panels had the task of correcting any mistakes in content, checking the plausibility of distractors, ensuring a uniformity of terminology, and imposing a consistent format which facilitates the answering of questions. Items which were found to have problems that could not be corrected were rejected. The remaining items were re-edited in the light of the reviewing panel's suggestions, and then assembled into trial-tests.

Trial-testing was conducted to provide empirical evidence on the performance of the items. It also provided basic statistical data, such as the percentage of trial students who responded correctly, as an aid for teachers when selecting specific items from the collection.

Trial-testing was conducted in 50 Victorian secondary schools during August and September 1979. Each trial test was tried in a balanced sample of country and metropolitan, government and non-government schools.

The average sample size was 150 with a range of 124 to 163 students. Only items which had a discrimination index of 0·20 or greater were included in this publication. Items which were rejected will be re-written and re-trialled with a view to their eventual inclusion in the item bank.

The processes of item writing, editing, and trial-testing will continue and a comprehensive coverage of all chemistry topics taught in the Commonwealth is planned.

The Australian Council for Educational Research Limited, Radford House, Frederick Street, Hawthorn, Vic 3122 · ACER CHEMTIC YEAR 12

Using the collection

A Uses for the Items

1 Production of diagnostic tests

A diagnostic test is one which attempts to identify learning difficulties experienced by students and enables the provision of some form of assistance in overcoming the problems that are identified.

Such a test should

- (a) contain a comprehensive range of items measuring the objectives of the syllabus area that is being evaluated, and
- (b) enable the provision of some form of feedback to the students after they have attempted the items.

Although it is possible to use each sub-collection as a test in its own right, it is hoped that teachers will devise their own diagnostic tests. The flexibility allowed by this format enables teachers to present a course in different ways without being committed to testing all of a particular section of the course at the one time.

Items have been constructed so that the choice of a particular distractor will allow the teacher to determine the nature of a student's error, and to advise the student of any appropriate remedial work necessary. Common errors could be discussed in class, and written explanations of the correct response (diagnostic aids) might be provided by the teacher.

Teachers should note that a sample answer sheet is provided at the back of the collection, and may serve as a master for the production of additional answer sheets.

2 Production of achievement tests

An achievement test is a test designed to measure a student's achievement in a particular syllabus area with a single score. Just as for a diagnostic test, it should contain a comprehensive range of items measuring the objectives of the syllabus area being evaluated. The degree of difficulty of an item can be approximately gauged by referring to the table of item facilities (giving the proportion of students who responded correctly to each item during trial-testing). As the collection includes items with a wide range of facilities, it is possible to prepare tests which

- (a) discriminate very well between students in the more able section of the class (using items with a low facility);
- (b) discriminate well between students in the weak section of the class (using items with a high facility); and
- (c) spread the students over a wide range of marks (using items which have an average facility of about 50 per cent).

(Facility values may vary as emphasis on topics changes.)

A sample achievement test, covering the whole course, is included in this collection. However, teachers may well wish to set their own achievement tests covering different sections of the course.

B Preparation of Tests

Test construction

In preparing a test, teachers should:

1 Identify the particular syllabus areas that are to be evaluated.

2 Select items which appear to evaluate these areas.

3 Write items, where necessary, to provide an adequate coverage of the areas.

4 Place the items in a logical order. Group items relevant to similar syllabus areas together. If possible, place the easier items early in the test, with the more difficult items towards the end of the test.

5 Place items based on the same stimulus material on the one page.

6 Ensure that one item does not supply the correct response for another item.

7 Check that the items are not ambiguous and that each has a correct response listed.

8 Prepare an answer key.

9 Ask another teacher to work through the draft, to identify errors and omissions, as well as providing a check on the answer key.

10 Prepare an answer sheet (a sample answer sheet is provided at the back of the collection).

C Selecting an Item

Teachers should first select from the topic axis the topic of interest. Each item is keyed to a particular section of the topic axis to enable rapid identification of its relevance. To further facilitate item identification, the items have been grouped in 7 units.[1]

Unit 1 has 30 items covering Sections 1.1 to 2.1 of the topic axis
Unit 2 has 30 items covering Sections 2.2 to 2.4 of the topic axis
Unit 3 has 30 items covering Sections 3.2 to 3.4 of the topic axis
Unit 4 has 30 items covering Sections 4.2 (i) to 4.2 (vii) of the topic axis
Unit 5 has 30 items covering Sections 4.3 (i) to 4.3 (iv) of the topic axis
Unit 6 has 30 items covering Sections 4.4 (i) to 4.4 (ivc) of the topic axis
Unit 7 has 45 items from all areas of the topic axis.

Unit 7 is intended as a model achievement test and contains a broad range of items with an average facility of approximately 50 per cent. This model will be useful to teachers preparing their own achievement tests. When preparing a test made up of items from this collection, teachers should bear in mind that during the trial-testing of items, most students completed an average of six items per ten minutes.

D Writing Additional Test Items

Multiple-choice items should incorporate the following points:

1 The stem and each alternative must read grammatically when taken together.
For example: Use of plural in the stem requires use of a plural in the alternatives.

2 The problem posed or the question asked must be clearly set out in the stem.

3 The whole item should be as brief as its proper presentation will allow.
For example: Avoid superfluous words.
Use one single idea in the stem.

---

[1] Victorian teachers will note that the first six units correspond to the six major areas of the VISE syllabus. Nine of the items relate to syllabus areas which will be deleted from the core of the course in 1981. These items (5-3, 5-4, 5-11, 5-16, 5-17, 5-22, 6-16, 6-17 and 7-35) are denoted in the text by asterisks.

4 To keep the alternatives brief, incorporate the major part of the idea in the stem

The following example illustrates this point:

Poor	*Better*
Chemistry is	Chemistry is a science that is concerned with
A a science that is concerned with the relationships and characteristics of matter.	**A** the relationships of living organisms, etc.
B a science that is concerned with the relationships of living organisms, etc.	**B** the relationships and characteristics of matter, etc.

5 Avoid a negative stem where possible.

If unavoidable,

either (i) emphasize *not*

or (ii) use: all of the following *except* one.
Which one?

6 All distractors should be equally attractive to the uninformed, yet the correct alternative must be unequivocally the best.

7 If the final alternative is an exclusion of the other alternatives, do not use 'none of the above'.

For example: **D** neither A, nor B, nor C.

8 All alternatives must be homogeneous in idea and style.

For example: Do not mix functions and structures.

9 Words such as 'all', 'never', 'always', 'only' should not be used indiscriminately.

10 Information presented in the stem must be factually correct.

11 Distractors must be clearly incorrect, and not merely incomplete.

For a more comprehensive treatment of test construction and item writing, see:

Izard, J. F., *Construction and Analysis of Classroom Tests*, ACER 1977.

Topic axis

1.1	The nuclear atom
1.2	Electronic structure of atoms
1.3	The periodic table
2.1	The mole and chemical formulae
2.2	Chemical reactions
2.3	Stoichiometric calculations
2.4	Chemical equilibrium
3.2	Transformation of energy by chemical reaction
3.3	Production of electrical energy by chemical reaction
3.4	Chemical reactions driven by electrical energy
4.2(i)	The elements C, Si
4.2(ii)	Hydrides of C, Si
4.2(iii)	Covalent bonding in compounds of C and Si
4.2(iv)	Chemistry of some oil and coal derivatives
4.2(v)	Polymers
4.2(vi)	Some molecules of biological importance
4.2(vii)	Oxides of C, Si
4.3(i)	The elements N, P.
4.3(ii)	Ammonia and phosphine
4.3(iii)	Oxides of nitrogen and phosphorus
4.3(iv)	The role of nitrogen and phosphorus in living systems
4.4(i)	Commercial sources of O, S, metals
4.4(ii)	The elements O, S; metals
4.4(iii)	Direct formation of oxides from metals
4.4(iva)	Oxides of sulfur; sulfuric acid
4.4(ivb)	Water
4.4(ivc)	Hydrogen peroxide

Answer key and item facilities

Unit 1			*Unit 2*		
Item	Correct Response	% Facility	Item	Correct Response	% Facility
1	B	33	1	A	22
2	B	77	2	A	82
3	D	21	3	C	75
4	C	74	4	A,B,E	40
5	C	69	5	E	77
6	F	85	6	B	77
7	A	75	7	C	25
8	A	77	8	D	54
9	D	61	9	B	50
10	C	72	10	B	53
11	E	43	11	D	30
12	A	30	12	B	77
13	B	69	13	C	47
14	C	53	14	B	54
15	C	58	15	A	27
16	B	85	16	B	39
17	A	30	17	D	88
18	C	85	18	D	78
19	B	58	19	B	38
20	D	76	20	D	65
21	C	55	21	A	68
22	D	90	22	C	57
23	D	30	23	A,C	25
24	B	81	24	B	34
25	D	74	25	A	45
26	B	64	26	B	34
27	D	81	27	A	50
28	C	13	28	D	69
29	B	82	29	E	65
30	D	41	30	C	60

Unit 3

Item	Correct Response	% Facility
1	A	92
2	D	89
3	D	85
4	D	73
5	C	78
[illegible]	D	65
7	B	66
8	A	65
9	C	42
10	B	52
11	A	56
12	C	40
13	C	45
14	C	73
15	B	33
16	C	65
17	C	61
18	A	69
19	D	50
20	A	65
21	D	56
22	B	32
23	D	77
24	D	86
25	A	67
26	B	48
27	D	22
28	C	54
29	D	56
30	A	46

Unit 4

Item	Correct Response	% Facility
1	C	90
2	B	80
3	C	69
4	D	83
5	C	76
6	C	72
7	B	78
8	D	92
9	D	82
10	C	43
11	C	68
12	D	83
13	C	62
14	D	83
15	D	83
16	B	76
17	B	68
18	D	76
19	B	66
20	B	30
21	C	78
22	A	92
23	D	83
24	B	57
25	C	86
26	B	56
27	B	67
28	B	46
29	D	67
30	D	76

Unit 5			*Unit 6*		
Item	Correct Response	% Facility	Item	Correct Response	% Facility
1	C	50	1	B	87
2	D	68	2	D	33
*3	B	90	3	A	35
*4	C	47	4	F	32
5	A	61	5	D	72
6	C	13	6	C	49
7	D	20	7	A	46
8	B	86	8	B	85
9	C	75	9	C	58
10	D	45	10	C	64
*11	B	63	11	B	20
12	C	49	12	C	32
13	D	76	13	A	93
14	D	58	14	C	87
15	A	63	15	D	78
*16	A	69	*16	B	52
*17	B	57	*17	A	76
18	B	71	18	C	50
19	A	35	19	D	39
20	C	65	20	D	48
21	C	40	21	C	72
*22	C	56	22	D	72
23	C	55	23	B	48
24	C	58	24	A	50
25	D	47	25	C	60
26	A	22	26	B	22
27	C	87	27	C	50
28	A	74	28	C	26
29	A	74	29	D	67
30	B	49	30	C	19

* Items relating to 1980 VISE syllabus core but being deleted from 1981 VISE syllabus core.

Item	Correct Response	% Facility
1	C	62
2	A	56
3	C	58
4	D	44
5	C	54
6	C	53
7	C	50
8	B	43
9	B	47
10	D	51
11	B	24
12	A	88
13	A	54
14	B	60
15	B	39
16	C	47
17	A	59
18	A	53
19	B	56
20	D	54
21	A	31
22	D	37
23	A	44
24	A	31
25	C	61
26	B	66
27	D	50
28	B	50
29	B	69
30	B	43
31	C	53
32	C	43
33	B	47
34	A,C,D	22
*35	C	80
36	C	50
37	B	76
38	B	35
39	C	36
40	A	58
41	D	64
42	B	61
43	D	61
44	C	66
45	B	57

* Items relating to 1980 VISE syllabus core but being deleted from 1981 VISE syllabus core.

CHEMTIC answer sheet

Name:
Class or Group:
Date:

Question No.	Answer	Question No.	Answer
1		26	
2		27	
3		28	
4		29	
5		30	
6		31	
7		32	
8		33	
9		34	
10		35	
11		36	
12		37	
13		38	
14		39	
15		40	
16		41	
17		42	
18		43	
19		44	
20		45	
21		46	
22		47	
23		48	
24		49	
25		50	

The Australian Council for Educational Research Limited, Radford House, Frederick Street, Hawthorn, Vic. 3122 — ACER CHEMTIC YEAR 12.

UNIT 1

Unit 1

1-1 The nucleus of an isotope of beryllium can be formed by the following nuclear reaction.

1.1
$$4\,^1_1H + 2\,^1_0n \rightarrow \,^6_4Be$$

The mass of the beryllium nucleus would be

A greater than the mass of the protons and neutrons.
B less than the mass of the protons and neutrons.
C equal to the mass of the protons and neutrons.
D equal to the mass of the protons, neutrons, and the nuclear binding energy.

1-2 The element mendelevium (Md) was first isolated by the bombardment of einsteinium atoms (Es) with α particles in the process

1.1
$$^{253}_{99}Es + \,^4_2He \rightarrow \,^{256}_{101}Md + X$$

The particle represented by X must be

A a proton.
B a neutron.
C an electron.
D a hydrogen atom.

1-3 It is believed that in a supernova, iron nuclei break down according to the equation

1.1
$$^{56}_{26}Fe \rightarrow 13\,^4_2He + 4\,^1_0n$$

Energy is required for this process.

As a result of this process, the mass of the system would

A depend on the conditions under which the reaction took place.
B remain unchanged.
C decrease.
D increase.

1-4 For a nuclear fusion to occur, two interacting nuclei must

1.1

A exert no electrostatic repulsions on each other.
B demonstrate a mutual electrostatic attraction.
C acquire sufficient kinetic energy to overcome an electrostatic repulsion.
D undergo a mass increase which accounts for the energy needed to overcome the net electrostatic repulsions.

1-5 The atomic number of an element is equal to

1.1

A the number of protons plus neutrons in a neutral atom of the element.
B the number of neutrons in a neutral atom of the element.
C the number of electrons in a neutral atom of the element.
D the weighted mean of the isotopic masses of the element.

1-6 An atom of rubidium $^{85}_{37}Rb$ is ionized to yield the Rb^+ ion.

1.1 In this ion, there are

A 85 neutrons.
B 85 electrons.
C 85 protons.
D 37 neutrons.
E 37 electrons.
F 37 protons.

1.2 **1-7** The characteristic wavelengths of light produced when sodium is placed in a flame can best be explained by the fact that

A when excited to any higher energy level, atoms emit energy in specific amounts, as the electrons drop back to a lower energy level.

B when excited to any higher energy level, atoms absorb only specific amounts of energy, which correspond to light of particular wavelengths.

C atoms are only able to absorb energy in specific quantities.

D after absorbing energy, atoms release a specific amount of energy depending on the amount of substance present.

1.2 **1-8** Which one of the following statements *best* expresses the idea of the Pauli principle?

A An orbital can never contain three or more electrons.

B An orbital must contain two electrons.

C An orbital may contain one electron.

D An orbital must always contain one or two electrons.

1.2 **1-9** An element has atomic number 27.
Its ground state electronic configuration is best expressed as

A $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 4p^6\ 5s^1$.

B $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 4d^6\ 5s^1$.

C $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$.

D $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^2$.

1.2 **1-10** Which of the following electronic configurations does *not* represent an atom in its lowest energy state?

A $1s^2\ 2s^2\ 2p^5$

B $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

C $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5\ 4s^1$

D $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$

The following information refers to the next four items.

Consider the following elements labelled V, W, X, Y and Z. For each element the electronic configuration is listed in the table below.

Element	*Electronic configuration*
V	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^6\ 6s^2$
W	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^3$
X	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^6\ 6s^2$
Y	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2$
Z	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$

1.2 **1-11** Which element belongs in the first transition series?

A V **B** W **C** X **D** Y **E** Z

1.2 **1-12** Which element occurs in Group II?

A V **B** W **C** X **D** Y **E** Z

1.2 **1-13** Which element occurs in Group V?

A V **B** W **C** X **D** Y **E** Z

1.2 **1-14** The number of orbitals in the f sub-shell is

A 2. **B** 5. **C** 7. **D** 14.

1.3 **1-15** In the *original* development of the periodic table, Mendeleev placed the then known elements in an order based on

A known properties and atomic numbers.
B known electronic structures and properties.
C atomic masses and known properties.
D the relative isotopic masses of the various known isotopes.

1.3 **1-16** Lithium and sodium have similar physical and chemical properties.
This is *best* explained by the fact that both elements

A are metals.
B have the same outer-shell electron configuration.
C have a low relative atomic mass.
D are in period 1 of the periodic table.

2.1 **1-17** The Avogadro Constant is equal to

A the number of molecules in one mole of oxygen gas.
B the number of atoms in 12 g of pure carbon.
C the number of atoms in 16 g of $^{16}_{8}O$.
D the number of elementary charges in one coulomb of charge.

2.1 **1-18** The mole is used as a measure of amount of substance in chemistry.
In terms of which one of the following is it defined?

A volume of particles
B size of particles
C number of particles
D concentration of particles

2.1 **1-19** 12 g exactly of $^{12}_{6}C$ contains $6 \cdot 0 \times 10^{23}$ atoms of $^{12}_{6}C$. Naturally occurring carbon contains 98·89% $^{12}_{6}C$ and 1·11% $^{13}_{6}C$ by mass. Hence, exactly 12 g of naturally-occurring carbon would contain

A more than $6 \cdot 0 \times 10^{23}$ atoms of $^{12}_{6}C$.
B fewer than $6 \cdot 0 \times 10^{23}$ atoms of $^{12}_{6}C$.
C atoms of $^{12}_{6}C$ and $^{13}_{6}C$ totalling $6 \cdot 0 \times 10^{23}$.
D exactly $6 \cdot 0 \times 10^{23}$ atoms of $^{12}_{6}C$.

2.1 **1-20** Chlorine atoms exist in two isotopic forms: $^{35}_{17}Cl$ and $^{37}_{17}Cl$.
If it were possible to completely separate these isotopes, it would follow that, assuming that all gases behaved ideally,

A 1 mol of $(^{37}_{17}Cl)_2$ gas would occupy a greater volume than 1 mol of $(^{35}_{17}Cl)_2$ gas under the same conditions.
B 1 g of $^{37}_{17}Cl$ would contain more atoms than 1 g of $^{35}_{17}Cl$.
C 1 dm^3 of $(^{37}_{17}Cl)_2$ gas would contain more molecules than 1 dm^3 of $(^{35}_{17}Cl)_2$ gas under the same conditions.
D 1 dm^3 of $(^{37}_{17}Cl)_2$ gas would have a greater mass than 1 dm^3 of $(^{35}_{17}Cl)_2$ gas under the same conditions.

2.1 **1-21** The element gallium has two isotopes of relative isotopic masses 68·95 and 70·95. Its relative atomic mass is 69·75. The percentage of isotope ^{69}Ga in naturally occurring gallium is

A 40. **B** 50. **C** 60. **D** 70. **E** 80.

2.1 **1-22** Naturally occurring boron consists of two isotopes with the following approximate percentage abundances.

$^{10}_{5}B$ 20% $^{11}_{5}B$ 80%

The best approximate relative atomic mass of boron is

A 10·0. **B** 10·2. **C** 10·5. **D** 10·8. **E** 11·0.

The Australian Council for Educational Research Limited, Radford House, Frederick Street, Hawthorn, Vic. 3122 — ACER CHEMTIC YEAR 12 – Unit 1.

1-23 A gaseous compound of nitrogen (A_r = 14) and oxygen (A_r = 16) is shown by experiment to have a relative molecular mass in the range of 50 to 100, and to contain a little over 30% nitrogen by mass. 2.1

The number of atoms of oxygen per molecule of the compound is

A 1 **B** 2 **C** 3 **D** 4 **E** 5

1-24 The percentage, by mass, of hydrogen in ammonium dichromate ($(NH_4)_2Cr_2O_7$) is (given A_r N = 14; H = 1; Cr = 52; O = 16) 2.1

A $\frac{1 \times 4 \times 100}{(14 + 4) + (52 \times 2) + (16 \times 7)}$

B $\frac{1 \times 4 \times 2 \times 100}{2(14 + 4) + (52 \times 2) + (16 \times 7)}$

C $\frac{1 \times 4 \times 2 \times 100}{(14 + 4) + (52 \times 2) + (16 \times 7)}$

D $\frac{1 \times 4 \times 100}{2(14 + 4) + (52 \times 2) + (16 \times 7)}$

1-25 Two vessels of equal volume contain helium gas (A_r = 4) and nitrogen gas (M_r = 28) respectively. 2.1

The gas in each vessel is at the same temperature and pressure.

When the gases in the two vessels are mixed, the percentage by mass of nitrogen in the mixture is

A $\frac{4 \times 100}{28 + 4}\%$ **B** $\frac{4 \times 100}{28}\%$ **C** $\frac{14 \times 100}{14 + 4}\%$ **D** $\frac{28 \times 100}{28 + 4}\%$

The following information refers to the next two questions.

A student had two flasks of identical volume.

He filled flask 1 with 1 mol of gas X (M_r = 20) at a temperature of 400 K, and flask 2 with 2 mol of gas Y (M_r = 80) at 100 K.

1-26 The ratio, pressure of gas X : pressure of gas Y, is equal to 2.1

A 4:1. **B** 2:1. **C** 1:1. **D** 1:2. **E** 1:4.

1-27 The ratio, number of molecules in flask 1 : number of molecules in flask 2, is equal to 2.1

A 4:1. **B** 2:1. **C** 1:1. **D** 1:2. **E** 1:4.

1-28 One mole of an ideal gas occupies 2.1

A 22·4 dm^3 at 273 °C and 101 300 Pa pressure.

B 44·8 dm^3 at 546 °C and 101 300 Pa pressure.

C 22·4 dm^3 at 273 °C and 202 600 Pa pressure.

D 44·8 dm^3 at 546 °C and 202 600 Pa pressure.

1-29 A flask, M, contains 1 mol of gas molecules at 250 K. 2.1

A flask, N, whose volume is the same as flask M, contains 2 mol of gas molecules. The pressure in flask N, however, is the same as that in flask M.

This could be explained if the gas in flask N

A had half the relative molecular mass of the gas in flask M.

B was at a temperature of 125 K.

C was composed of diatomic molecules.

D had half as many molecules as the gas in flask M.

1-30 If, at a fixed pressure, 2·20 g of a gas at 300 K occupies the same volume as 2·02 g of nitrogen gas at 290 K, then the molar mass of this gas is (given A_r N = 14) 2.1

A $\frac{2 \cdot 20 \times 14}{2 \cdot 02}$ g.

B $\frac{2 \times 2 \cdot 20 \times 14}{2 \cdot 02}$ g.

C $\frac{2 \cdot 20 \times 300 \times 14}{2 \cdot 02 \times 290}$ g.

D $\frac{2 \times 2 \cdot 20 \times 300 \times 14}{2 \cdot 02 \times 290}$ g.

E $\frac{2 \times 2 \cdot 20 \times 290 \times 14}{2 \cdot 02 \times 300}$ g.

UNIT 2

2.2 Chemical reactions
2.3 Stoichiometric calculations
2.4 Chemical equilibrium

2.2 **2-1** A reduction reaction may often involve the

A addition of hydrogen.
B removal of hydrogen.
C addition of hydrogen ion.
D removal of hydrogen ion.

2.2 **2-2** In which of the following compounds does the underlined element have an oxidation number of +2?

A $\underline{\mathrm{Zn}}(\mathrm{OH})_2$ **B** $\underline{\mathrm{Cr}}\mathrm{O_2Cl_2}$ **C** $\underline{\mathrm{N}}\mathrm{O_2}$ **D** $\underline{\mathrm{C}}\mathrm{H_3OH}$

2.2 **2-3** Concentrated sulfuric acid is able to act as an oxidising agent.
Which one of the following equations illustrates this ability?

A $2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$
B $NaCl(s) + H_2SO_4(aq) \rightarrow NaHSO_4(aq) + HCl(aq)$
C $Zn(s) + 2H_2SO_4(aq) \rightarrow ZnSO_4(aq) + 2H_2O(l) + SO_2(g)$
D $2NH_3(g) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$

2.2 (4.3(ii)) **2-4** Which **one or more** of the following reactions of nitrogen oxides are redox reactions?

A $2NO + O_2 \rightarrow 2NO_2$
B $2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$
C $2NO_2 \rightarrow N_2O_4$
D $N_2O_3 + H_2O \rightarrow 2HNO_2$
E $3NO \rightarrow N_2O + NO_2$

2.2 **2-5** The permanganate ion, MnO_4^-, can oxidize H_2S to elemental sulfur, according to the following equations:

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$
$$H_2S \rightarrow S + 2H^+ + 2e^-$$

When the redox reaction occurs, the ratio of number of mole of MnO_4^- reacting to number of mole of S produced is

A 1:1. **B** 1:2. **C** 5:1. **D** 5:2. **E** 2:5.

2.3 **2-6** Heptane burns in air according to the equation

$$C_7H_{16}(l) + 11O_2(g) \rightarrow 7CO_2(g) + 8H_2O(g).$$

What volume of CO_2 is produced at STP, by the complete combustion of 1·0 g of heptane?
(A_r H = 1; C = 12)

A 0·224 dm³ **B** 1·57 dm³ **C** 1·79 dm³ **D** 2·46 dm³

2.3 **2-7** A sample of impure limestone had a mass of 10·0 g. When heated strongly, various volatile materials were evolved, but the CO_2 component was isolated and absorbed by passing it through CaO which showed a mass increase of 2·20 g.
Based on these figures, the carbonate ion (CO_3^{2-}) content in the limestone was
(given A_r Ca = 40; C = 12; O = 16)

A 2·2% **B** 22·0% **C** 30·0% **D** 50·0%

2-8 The mass of anhydrous sodium carbonate required to make up exactly 2 dm^3 of 0·025 M solution is (A_r Na 23; C 12; O 16) 2.3

A $2 \times 0{\cdot}025 \times (23 + 12 + [3 \times 16])$ g.

B $\frac{0{\cdot}025 \times (23 + 12 + [3 \times 16])}{2}$ g.

C $\frac{2 \times 0{\cdot}025}{(23 + 12 + [3 \times 16])}$ g.

D $2 \times 0{\cdot}025 \times ([2 \times 23] + 12 + [3 \times 16])$ g.

E $\frac{0{\cdot}025 \times ([2 \times 23] + 12 + [3 \times 16])}{2}$ g.

The following information refers to the next two items.

2·45 g of pure potassium chlorate ($KClO_3$) was quantitatively decomposed to produce potassium chloride (KCl) and oxygen. The potassium chloride was dissolved in water and treated with a 0·2 M silver nitrate solution ($AgNO_3$) producing a precipitate of silver chloride.

(A_r N = 14, O = 16; K = 39; Cl = 35·5; Ag = 108)

2-9 The volume of oxygen released from 2·45 g of $KClO_3$ at STP is 2.3

A $0{\cdot}02 \times 22{\cdot}4\ dm^3$.
B $0{\cdot}03 \times 22{\cdot}4\ dm^3$.
C $0{\cdot}04 \times 22{\cdot}4\ dm^3$.
D $0{\cdot}06 \times 22{\cdot}4\ dm^3$.

2-10 The volume of silver nitrate solution required for the complete reaction of the potassium chloride solution is 2.3

A $\frac{0{\cdot}2 \times 1000}{0{\cdot}02}\ cm^3$.
B $\frac{0{\cdot}02 \times 1000}{0{\cdot}2}\ cm^3$.
C $\frac{0{\cdot}2 \times 1000}{0{\cdot}04}\ cm^3$.
D $\frac{0{\cdot}02 \times 1000}{0{\cdot}4}\ cm^3$.

2-11 The volume of 0·1 M H_2SO_4 solution required to prepare 5·62 g of hydrated iron (III) sulphate (M_r = 562) from iron (III) oxide is 2.3

A 10 cm^3. **B** 30 cm^3. **C** 100 cm^3. **D** 300 cm^3. **E** 1 dm^3.

2-12 When 20 cm^3 of 1 M $BaCl_2$ solution is added to 40 cm^3 of 2 M K_2SO_4 solution, the mass of the $BaSO_4$ precipitate formed is (given A_r K = 39; S = 32; O = 16; Ba = 137; Cl = 35·5) 2.3

A 2·33 g. **B** 4·66 g. **C** 9·32 g. **D** 18·64 g.

The following information refers to the next four items.

A solution is prepared by adding 250 cm^3 of 0·05 M $Ba(OH)_2$ solution to 250 cm^3 of a 0·02 M solution of NaOH.

2-13 The molarity of the solution with respect to the OH^- ion is 2.3

A 0·03 M. **B** 0·04 M. **C** 0·06 M. **D** 0·07 M. **E** 0·12 M.

2[illegible] The molarity of the solution with respect to the Na^+ ion is 2.3

A 0·005 M. **B** 0·01 M. **C** 0·02 M. **D** 0·03 M. **E** 0·04 M.

2-15 What would be the minimum volume of 0·05 M H_2SO_4 required to precipitate the Ba^{2+} ions from 50 cm^3 of the solution as $BaSO_4$? 2.3

A 25 cm^3 **B** 50 cm^3 **C** 100 cm^3 **D** 250 cm^3

2-16 50 cm^3 of the solution required 60 cm^3 of an HCl solution for complete neutralization. The molarity of the HCl was 2.3

A 0·03 M. **B** 0·05 M. **C** 0·06 M. **D** 0·10 M. **E** 0·12 M.

2-17 A student prepares a solution that has a pH of 8·8. The concentration of H_3O^+ in the solution is 2.3

A 8·8 M. **B** 8×10^{-8} M. **C** 10^{-8} M. **D** $10^{-8{\cdot}8}$ M.

The Australian Council for Educational Research Limited. Radford House, Frederick Street, Hawthorn, Vic. 3122 — ACER CHEMTIC YEAR 12 — Unit 2.

2.3 **2-18** The sourness of a substance is a reasonable guide to its acidity sourness increases with increasing acidity.

If solution A was more sour than solution B, then it is likely that

- **A** solution A was at a higher pH than solution B.
- **B** solution A has more OH^- ions in solution than solution B.
- **C** solution A has a higher concentration of H_2O molecules than solution B.
- **D** solution A has a higher concentration of H_3O^+ ions than solution B.

2.3 **2-19** A student titrated an approximately 2 M solution of acetic acid (CH_3COOH) into a 25·0 cm^3 sample of 2·0 M NaOH.

The equation for the reaction is

$$CH_3COOH + NaOH \rightarrow H_2O + CH_3COONa.$$

The indicator used changes colour at a pH of 7·3, while the pH of a 1 M solution of CH_3COONa is 8·5.

The equivalence point of the titration (the point where equal moles of reactants have been added) will occur

- **A** after the end point has been reached.
- **B** before the end point is reached.
- **C** at exactly the same titre as the end point.
- **D** either before or after the end point, but additional information is necessary to decide this.

2.3 **2-20** A mixture of nitrogen and hydrogen was allowed to achieve equilibrium at a constant temperature. Analysis showed that the mixture contained 2·0 mol N_2, 3·0 mol H_2 and 1·0 mol NH_3. The number of mol of H_2 originally present was

- **A** $3{\cdot}0 + (2 \times 2{\cdot}0)$.
- **B** $3{\cdot}0 + (\frac{1}{3} \times 2{\cdot}0)$.
- **C** $3{\cdot}0 + (\frac{2}{3} \times 1{\cdot}0)$.
- **D** $3{\cdot}0 + (\frac{3}{2} \times 1{\cdot}0)$.

2.4 **2-21** Which one of the following procedures is *not* likely to increase the rate of reaction of a gaseous system?

- **A** increasing the volume of the system at constant temperature
- **B** increasing the temperature of the system at constant volume
- **C** increasing the concentration of the reactants at constant temperature
- **D** increasing the pressure of the system at constant temperature

2.4 **2-22** If a catalyst is added to a reversible reaction at equilibrium, then it alters the rate of

- **A** the forward reaction only.
- **B** the back reaction only.
- **C** both the forward and back reactions equally.
- **D** the forward reaction more than the rate of the back reaction.

2.4 **2-23** In which **one or more** of the following chemical equilibrium systems will the position of equilibrium be shifted to the right by an increase in volume?

- **A** $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$
- **B** $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$
- **C** $C_3H_8(g) + 5O_2(g) \rightleftharpoons 3CO_2(g) + 4H_2O(g)$
- **D** $Cl_2(g) + 3F_2(g) \rightleftharpoons 2ClF_3(g)$

2.4 **2-24** Nitrogen reacts with hydrogen according to the equation

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

K for this reaction, at 475°C, is 0·010 M^{-2}.

If, in such a system at equilibrium the concentration of NH_3 was 10^{-3} M, and the concentration of N_2 was 10^{-1} M, then the concentration of H_2 was

A 1 M. **B** 0·1 M. **C** 0·01 M. **D** 0·001 M. **E** 0·0001 M.

The following information refers to the next two items.

Carbon monoxide and chlorine react according to the equation

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$$

The forward reaction is exothermic.

2.4 **2-25** If a mixture of CO, Cl_2, and $COCl_2$ at equilibrium at 1000 °C is cooled to 500 °C at constant volume, then, when the new equilibrium is attained,

A the concentration of CO will decrease.
B the concentration of $COCl_2$ will decrease.
C the value of K will decrease
D the rate of reaction must remain unchanged.

2.4 **2-26** If the volume of an equilibrium mixture of CO, Cl_2, and $COCl_2$ is halved, by increasing the pressure at constant temperature, then, at the new equilibrium

A the concentration of CO will have decreased.
B the concentration of $COCl_2$ will have increased.
C the value of K will increase.
D the rate of reaction must remain unchanged.

2.4 (4.3(ii)) **2-27** A closed vessel contains nitrogen and hydrogen in equilibrium with NH_3, as shown by the equation below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2\,NH_3(g) \quad \Delta H = -92\ kJ\ mol^{-1}$$

Which one of the following procedures will shift the equilibrium position to the right?

A decreasing the volume of the system
B increasing the temperature of the system
C introduction of an inert gas into the system
D addition of a catalyst to the system

The following information refers to the next three items.

Some hydrogen and iodine were placed in a sealed vessel and heated to 500 °C, where equilibrium was established according to the equation

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

The reaction is endothermic.

The mixture was then quickly cooled so that no further reaction took place, and the equilibrium was undisturbed. Some I_2 was removed and replaced by an equal amount of radioactive iodine, I_2^*. Equilibrium was then re-established at 500 °C.

2.4 **2-28** Upon re-establishment of the equilibrium mixture, the species present would be

[illegible] H_2; I_2^*; HI^*

B H_2; HI; I_2^*; HI^*

C H_2, I_2, HI, HI^*

D H_2; I_2; HI; I_2^*; HI^*

2.4 **2-29** The volume of the container housing the equilibrium mixture was then halved, while keeping the temperature constant.

It would follow that

A the mass of I_2^* would increase.

B the mass of I_2^* would decrease.

C the mass of HI would decrease.

D the mass of I_2 would increase.

E there would be no change in the relative masses of the reactants and product.

2.4 **2-30** The volume of the container was then returned to its original value and the temperature was increased to 600 °C.

It would follow that, compared to the original equilibrium situation,

A $[HI^*]$ and $[I_2^*]$ would both increase.

B $[HI^*]$ and $[I_2^*]$ would both decrease.

C $[HI^*]$ would increase but $[I_2^*]$ would decrease.

D $[HI^*]$ would decrease but $[I_2^*]$ would increase.

E the reagents would remain unchanged.

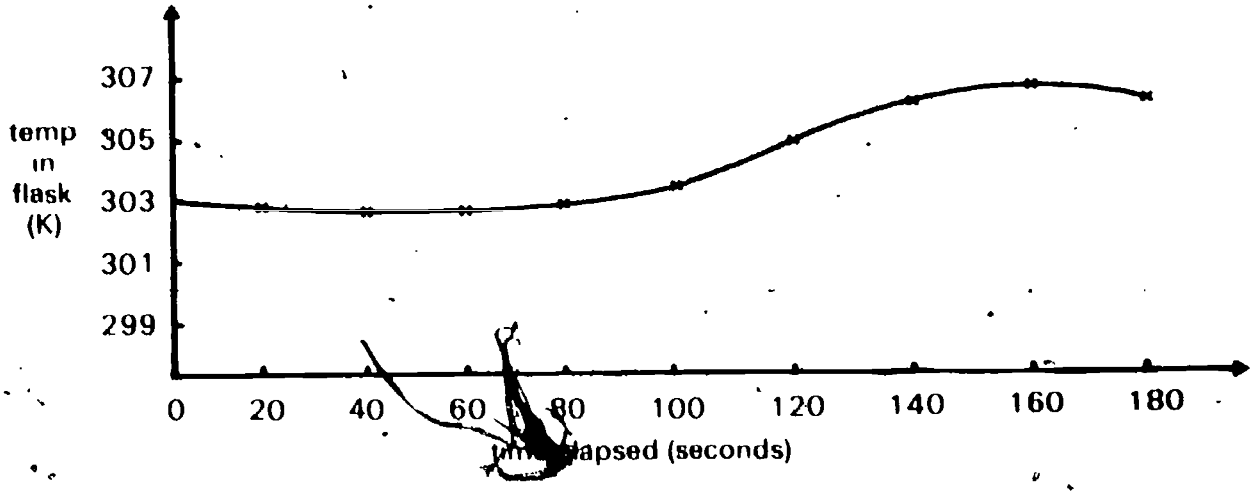
UNIT 3

3.2 Transformation of energy by chemical reaction
3.3 Production of electrical energy by chemical reaction
3.4 Chemical reactions driven by electrical energy

The following information refers to the next two items.

150 cm^3 of water at 303 K was placed in an insulated flask, and the temperature measured at 20 second intervals for 3 minutes. The results are shown on the graph below. After 60 seconds, 0·1 mole of the compound NaX was added to the water.

Room temperature was 293 K throughout the experiment.



3-1 The solution process $NaX(s) + aq \rightarrow Na^+(aq) + X^-(aq)$ is

3.2 **A** exothermic. **C** endergonic.

B endothermic. **D** thermoneutral.

3-2 The sign for ΔH in the above reaction is

3.2 **A** negative, as the system gradually gains heat from its surroundings.

B positive, as the water tends to gain energy.

C positive, as the solid tends to lose energy to the water.

D negative, as the system produces heat which it gradually loses to its surroundings.

3-3 For the reaction $H_2(g) + X_2(g) \rightarrow 2HX(g)$ $\Delta H = -110$ kJ

3.2 ΔH for the reaction $HX(g) \rightarrow \frac{1}{2}H_2(g) + \frac{1}{2}X_2(g)$ is

A -220 kJ. **C** -55 kJ. **E** $+110$ kJ.

B -110 kJ. **D** $+55$ kJ.

3-4 For the reaction $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$ $\Delta H = -56$ kJ mol^{-1}

3.2 When 10 cm^3 of 0·25 M HCl solution is reacted with 20 cm^3 of 0·15 M NaOH solution, the heat change occurring has the value

A 56 J. **C** 3 × 56 J. **E** 0·5 × 56 J.

B 5·5 × 56 J. **D** 2·5 × 56 J.

3-5 The equation below represents the solution of sodium thiosulphate in excess water.

3.2 $Na_2S_2O_3(s) + aq \rightarrow 2Na^+(aq) + S_2O_3^{2-}(aq)$ $\Delta H = +7·15$ kJ mol^{-1}

When 0·010 mole of sodium thiosulphate is dissolved in 100 cm^3 of pure water in a thermally insulated container,

A the water will become warmer due to the reaction.

B the water will remain at the same temperature but heat will be given off to the surroundings.

C the water will become colder due to the reaction.

D the water will remain at the same temperature but heat will be absorbed from the surroundings.

3.2 **3-6** The combustion of the fuel gas butane (C_4H_{10}) proceeds according to the equation

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l) \qquad \Delta H \quad 5760\ \text{kJ}$$

The mass of butane (M_r 58) which must be burned in order to produce 1·0 kJ of heat according to the equation given is

A $\frac{1\cdot0}{5760} \times 58$ g.

B $\frac{1\cdot0}{5760} \times \frac{58}{2}$ g.

C $5760 \times 2 \times 58$ g.

D $\frac{1\cdot0}{5760} \times 2 \times 58$ g

E $\frac{5760}{2} \times 1\cdot0 \times 58$ g.

3.2 **3-7** Consider the following thermochemical equations.

$$CaSO_4(s) + aq \rightarrow Ca^{2+}(aq) + SO_4^{2-}(aq) \qquad \Delta H = -66\cdot5\ \text{kJ mol}^{-1}$$

$$CaSO_4.5H_2O(s) + aq \rightarrow Ca^{2+}(aq) + SO_4^{2-}(aq) + 5H_2O(l) \qquad \Delta H = +11\cdot7\ \text{kJ mol}^{-1}$$

A mixture of solid $CaSO_4$ and $CaSO_4.5H_2O$ was added to a volume of water in a thermally insulated vessel, and no temperature change occurred. If the mixture contained 2·0 mol of $CaSO_4$, the number of mole of $CaSO_4.5H_2O$ present in the mixture was

A $\frac{2\cdot0 \times 11\cdot7}{66\cdot5}$.

B $\frac{2\cdot0 \times 66\cdot5}{11\cdot7}$.

C $\frac{1 \times 11\cdot7}{2\cdot0 \times 66\cdot5}$.

D $\frac{1 \times 66\cdot5}{2\cdot0 \times 11\cdot7}$.

3.2 **3-8** Which of the following reactions would be least likely to occur in the furnace of a fossil fuel power station?

A $2H_2 + O_2 \rightarrow 2H_2O$

B $C + O_2 \rightarrow CO_2$

C $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

D $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$

3.2 **3-9** In Victoria, brown coal deposits will be able to supply the State's electrical needs for many years to come.

In a coal burning power station,

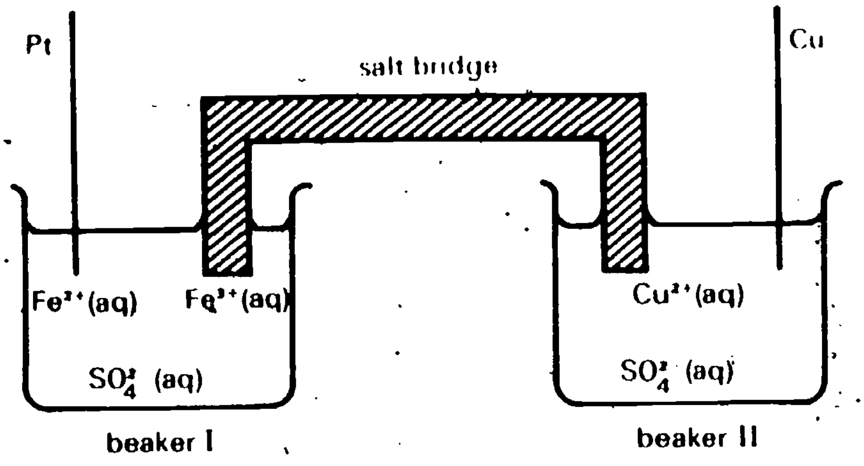
A all the chemical bond energy released from the coal is converted into electrical energy.

B all the heat energy released from the coal is converted into electrical energy.

C all the chemical bond energy released from the coal is converted into either electrical or heat energy.

D all the heat energy released from the coal is converted into either electrical or chemical bond energy.

The following diagram and data refers to the next four items.



$Fe^{3+} + e^- \rightarrow Fe^{2+}$ $E^0 = 0{\cdot}77$ V

$Cu^{2+} + 2e^- \rightarrow Cu$ $E^0 = 0{\cdot}34$ V

$Fe^{2+} + 2e^- \rightarrow Fe$ $E^0 = -0{\cdot}41$ V

Concentrations are 1 M with respect to the ions listed.

3-10 For the above system
3.3 **A** there will be no electron flow in the wire.
B electrons will flow in the wire from Cu to Pt.
C electrons will flow in the wire from Pt to Cu.
D electrons will flow through the salt bridge from the $Cu^{2+}(aq)$ solution to the $Fe^{2+}(aq)$ solution.
E electrons will flow through the salt bridge from the $Fe^{2+}(aq)$ solution to the $Cu^{2+}(aq)$ solution.

3-11 For the system illustrated, the electrode polarity will be
3.3 **A** Pt positive, Cu negative. **C** Pt and Cu both at zero potential.
B Pt negative, Cu positive.

3-12 If a KNO_3 containing salt bridge was used in the above system, then,
3.3 **A** K^+ ions migrate into Beaker I, and are replaced in the salt bridge by Cu^{2+} ions from Beaker II.
B NO_3^- ions migrate into Beaker I, and are replaced in the salt bridge by SO_4^{2-} ions from Beaker II.
C K^+ ions migrate into Beaker I, and NO_3^- ions migrate into Beaker II.
D K^+ ions migrate into Beaker II, and NO_3^- ions migrate into Beaker I.

3-13 If the platinum electrode is replaced by an iron electrode, then
3.3 **A** there will be no electron flow in the wire.
B electrons will flow in the wire from Cu to Fe.
C electrons will flow in the wire from Fe to Cu.
D electrons will flow through the salt bridge from the $Cu^{2+}(aq)$ solution to the $Fe^{2+}(aq)$ solution.
E electrons will flow through the salt bridge from the $Fe^{2+}(aq)$ solution to the $Cu^{2+}(aq)$ solution.

3-14 When comparing galvanic cells with electrolysis cells, it is true to say that
3.3 **A** the anode is positive, and the cathode is negative in each case.
B reduction occurs at the negative electrode in a galvanic cell.
C reduction occurs at the cathode in both cases.
D oxidation occurs at the cathode in an electrolysis cell.

The next two items refer to the following table of E^0 values.

$Br_2 + 2e^- \rightarrow 2Br^-$ $E^0 = 1\cdot087$ V
$Cl_2 + 2e^- \rightarrow 2Cl^-$ $E^0 = 1\cdot358$ V
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ $E^0 = 1\cdot33$ V
$I_2 + 2e^- \rightarrow 2I^-$ $E^0 = 0\cdot535$ V
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ $E^0 = 1\cdot491$ V

3.3 **3-15** From this table, we would predict that

A bromine molecules will be oxidised to bromide ions by a solution containing iodide ions.
B dichromate ions will not oxidise iodide ions unless an acid solution is present.
C permanganate ions will only reduce a chlorine solution in the presence of H^+ ions.
D dichromate ions will reduce chlorine solutions, but not a solution of permanganate ions.

3.3 **3-16** The E^0 for the reaction $2NO_3^- + 10H^+ + 8e^- \rightarrow N_2O + 5H_2O$ is $1\cdot18$ V.
This means that an acidic solution of NO_3^- would be reduced by solutions of

A Cl^- or Cr^{3+}.
B MnO_4^- or $Cr_2O_7^{2-}$.
C Br^- or I^-.
D MnO_4^- or Br^-.

3.3 **3-17** Which one of the standard electrodes whose half cell reactions are given below would give the largest EMF when paired with a standard calomel electrode ($E^0 = 0\cdot24$ V)?

A $Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$ $E^0 = +0\cdot77$ V
B $Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$ $E^0 = -0\cdot23$ V
C $Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$ $E^0 = -0\cdot76$ V
D $Ag^+(aq) + e^- \rightarrow Ag(s)$ $E^0 = +0\cdot80$ V

3.3 **3-18** Use the following standard electrode potentials to determine which of the species listed will be reduced by hydrogen sulphide.

$Cl_2 + 2e^- \rightarrow 2Cl^-$ $E^0 = 1\cdot36$ V
$Br_2 + 2e^- \rightarrow 2Br^-$ $E^0 = 1\cdot07$ V
$Fe^{3+} + e^- \rightarrow Fe^{2+}$ $E^0 = 0\cdot77$ V
$I_2 + 2e^- \rightarrow 2I^-$ $E^0 = 0\cdot53$ V
$S + 2H^+ + 2e^- \rightarrow H_2S$ $E^0 = 0\cdot14$ V
$Fe^{2+} + 2e^- \rightarrow Fe$ $E^0 = -0\cdot41$ V

A Cl_2, Br_2, Fe^{3+}, I_2
B Cl^-, Br^-, Fe^{2+}, I^-
C Fe^{2+} only
D Fe only

3.3 **3-19** Car batteries are of the lead-acid type. The overall reaction which occurs as the battery discharges is

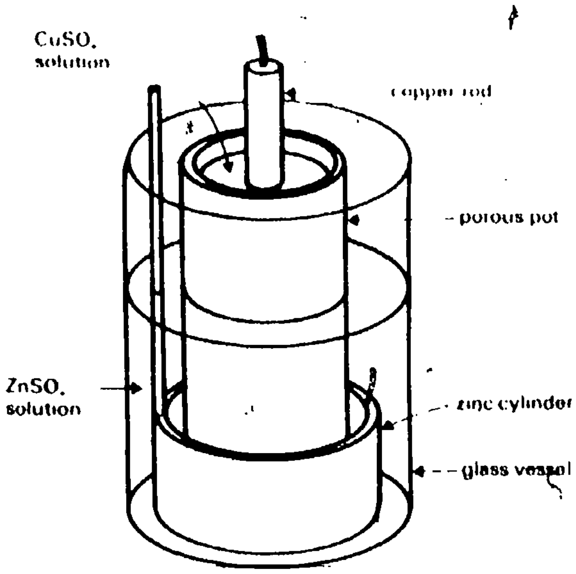
$$Pb(s) + PbO_2(s) + 4H^+ + 2SO_4^{2-} \rightarrow 2PbSO_4 + 2H_2O$$

In the *recharging* process,

A the pH of the solution in the battery increases.
B all Pb^{2+} ions in the battery are oxidised to Pb^{4+} ions.
C the lead plates in the battery dissolve as Pb^{2+} ions are produced.
D Pb^{2+} ions are either oxidised or reduced depending on the electrode they are near.

The Australian Council for Educational Research Limited. Radford House, Frederick Street, Hawthorn, Vic. 3122 – ACER CHEMTIC YEAR 12 – Unit 3.

3.3 **3-20** The diagram shows a simple primary cell (the Daniell cell).



$E^0_{Cu^{2+},Cu}$ 0·34 V

$E^0_{SO_4^{2-},SO_2}$ 0·20 V

$E^0_{Zn^{2+},Zn}$ −0·76 V

In this cell, the reactant involved at the cathode is

A Cu^{2+} **B** H_2O **C** Zn^{2+} **D** SO_4^{2-}

3.3 **3-21** The nickel-cadmium cell commonly used in electronic calculators has as its overall cell reaction

$$Ni_2O_3(s) + 3H_2O(l) + Cd(s) \rightleftharpoons Cd(OH)_2(s) + 2Ni(OH)_2(s)$$

and has an EMF of 1·3 V.

To recharge this cell it would be necessary to

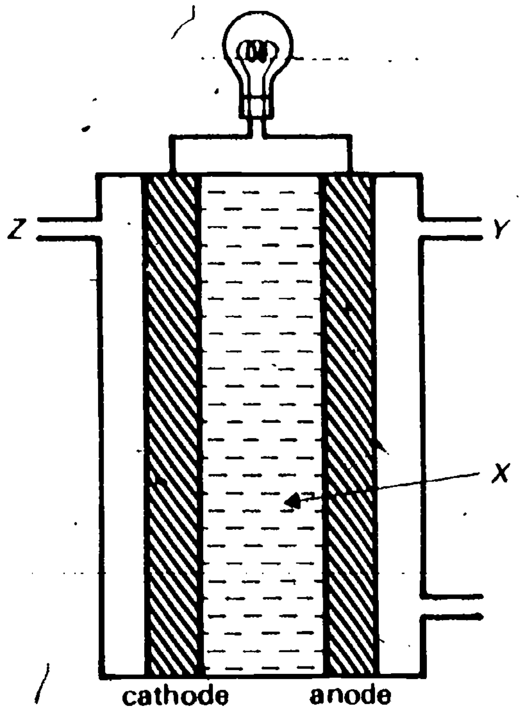
A apply a potential of 1·3 V across the cell, with the Cd electrode connected to the positive terminal of the power source.

B apply a potential of 1·3 V across the cell, with the Cd electrode connected to the negative terminal of the power source.

C apply a potential of more than 1·3 V across the cell, with the Cd electrode connected to the positive terminal of the power source.

D apply a potential of more than 1·3 V across the cell, with the Cd electrode connected to the negative terminal of the power source.

3.3 **3-22** The diagram below shows a cross-section through a functioning H_2 O_2 fuel cell.



Which **one or more** of the following statements is correct?

A The anode consists of a strip of platinum.
B Label X refers to a solution of an electrolyte.
C Label Y refers to the oxygen gas outlet.
D Label Z refers to the hydrogen gas inlet.

3.4 **3-23** Which **one** of the following would be least likely to affect either the rate, or the type of reaction, at a fully immersed electrode in an electrolysis cell?

A increasing the area of the electrodes
B varying the potential difference across the electrodes
C increasing the concentration of the electrolyte
D increasing the volume of the solution to be electrolysed

3.4 **3-24** Which of the following best identifies the cathode in an electrolytic cell?

A the electrode at which cations are discharged
B the electrode at which no gas can be evolved
C the electrode at which OH^- ions are produced
D the electrode at which reduction occurs

3.4 **3-25** The numerical value of the Faraday Constant (F) is given as 96487. This value represents

A the number of coulomb carried by 1 mol of charge.
B the number of electrons corresponding to 1 coulomb of charge.
C the number of electrons corresponding to 1 mol of electric charge.
D the number of ions discharged by the passage of 1 mol of electrons.

3.4 **3-26** Electrolysis of a concentrated solution of sodium chloride is an important industrial process. In this process, which uses a potential difference of 5 V,

A oxygen is produced at the anode and chlorine is produced at the cathode.

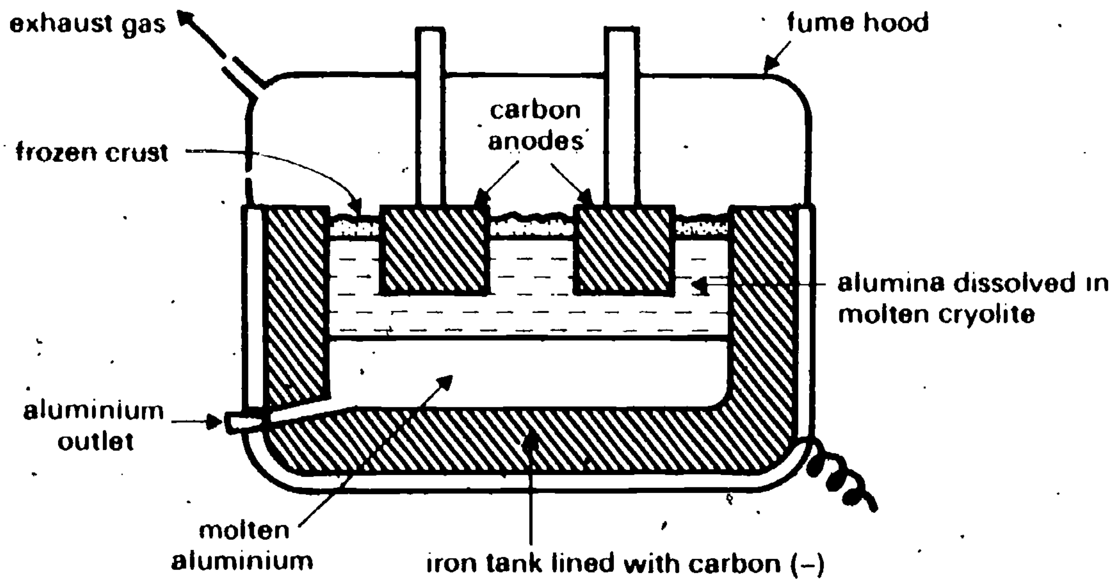
B chlorine is produced at the anode and hydrogen is produced at the cathode.

C oxygen is produced at the anode and hydrogen is produced at the cathode.

D OH^- ions are produced at the anode and chlorine is produced at the cathode.

E chlorine is produced at the cathode and sodium is produced at the anode.

3.4 **3-27** The diagram shows an electrolysis cell for the extraction of aluminium metal.



Which one of the following statements about this apparatus is correct?

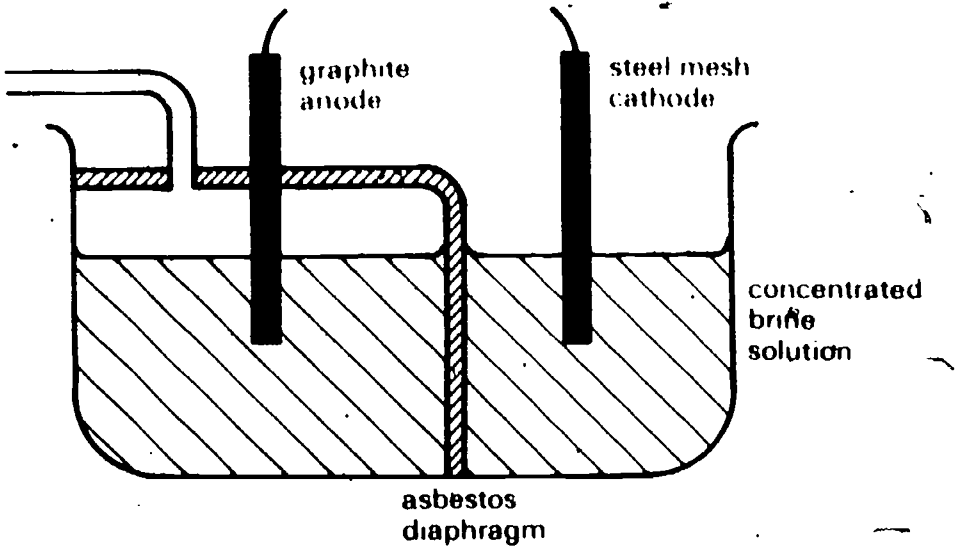
A Carbon anodes are used because they are unreactive.

B At the cathode, alumina is reduced to aluminium and chlorine.

C The aluminium must be continually removed so that it does not interfere with the carbon cathode.

D Cryolite is used as a solvent because alumina reacts preferentially at the electrodes.

3.4 **3-28** The diagram shows a simplified representation of a commercial electrolysis cell the Nelson Cell



When this cell is used in industry, the products are

A chlorine and oxygen.
B chlorine and hydrogen.
C chlorine, hydrogen and sodium hydroxide.
D sodium hydroxide and hydrogen.

3.4 **3-29** In the electrolytic manufacture of tin plate, a solution of $K_2Sn(OH)_6$ is used as the electrolyte. The mass of tin that would be deposited after electrolysis for 1 hour with a current of 0·3 A would be (given $F = 96487 C mol^{-1}$; $A_r Sn = 118 \cdot 69$)

A $\frac{0 \cdot 3 \times 118 \cdot 69}{96487 \times 2}$

B $\frac{0 \cdot 3 \times 60 \times 118 \cdot 69}{96487 \times 2}$

C $\frac{0 \cdot 3 \times 60 \times 60 \times 118 \cdot 69}{96487 \times 2}$

D $\frac{0 \cdot 3 \times 60 \times 60 \times 118 \cdot 69}{96487 \times 4}$

E $\frac{0 \cdot 3 \times 60 \times 96487}{2 \times 118 \cdot 69}$

F $\frac{0 \cdot 3 \times 60 \times 60 \times 96487}{4 \times 118 \cdot 69}$

3.4 **3-30** A student wishes to determine the Avogadro Constant by electrolysing a solution of copper sulfate.

Which one of the following quantities is *not* needed for his determination?

A the concentration of the copper sulfate solution
B the mass of copper deposited
C the amount of electricity in coulomb, passed through the electrolyte
D the value, in coulomb, of 1 elementary charge

UNIT 4

4.2(i) The elements C, Si
4.2(ii) Hydrides of C, Si
4.2(iii) Covalent bonding in compounds of C and Si
4.2(iv) Chemistry of some oil and coal derivatives
4.2(v) Polymers
4.2(vi) Some molecules of biological importance
4.2(vii) Oxides of C, Si

Unit 4

4.2(ii) **4-1** In the fractional distillation of crude oil,

- **A** molecules are split into smaller molecules.
- **B** alkanes are converted to alkenes.
- **C** hydrocarbons are separated according to their boiling temperatures.
- **D** aromatic hydrocarbons are produced from alkanes.

4.2(ii) **4-2** Over 50 % of Bass Strait crude oil consists of fractions with a relative molecular mass of 150 or more, yet 80 % of the crude oil is converted to petrol, which contains fractions with relative molecular masses of 120 or less.

This is achieved by

- **A** vacuum distillation of the heavy hydrocarbon fractions.
- **B** thermally or catalytically cracking the heavier hydrocarbon components.
- **C** hydrogenation of the undesired fractions.
- **D** catalytic reforming of the heavy hydrocarbon fractions.

4.2(ii) **4-3** A common feature of the alkanes is that they all have

- **A** the same empirical formula.
- **B** the same molecular formula.
- **C** similar chemical properties.
- **D** similar relative molecular masses.

4.2(ii) **4-4** When a hydrocarbon was burned in excess air, the volumes of water vapour and carbon dioxide gas produced were in the ratio 2 : 1.

If the volumes of both gases were measured at the same temperature and pressure the hydrocarbon could be

- **A** benzene.
- **B** ethane.
- **C** ethylene (ethene).
- **D** methane.

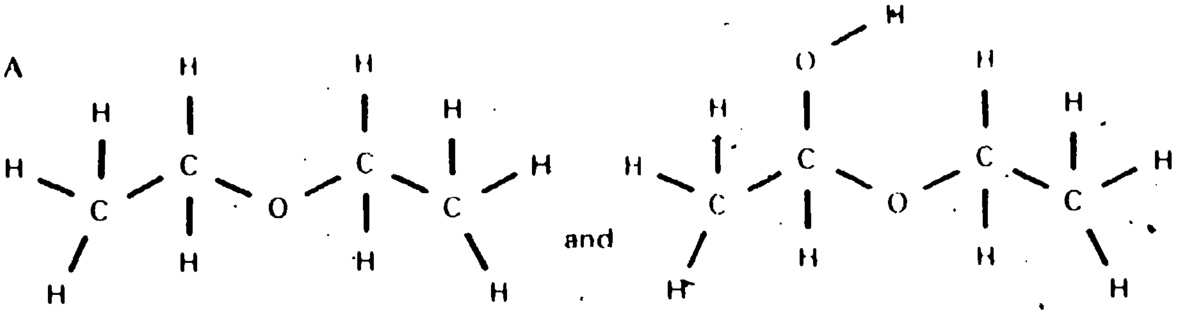
4.2(ii) **4-5** The major hydrocarbon constituent of petrol is octane – C_8H_{18}. Of the following, the equation which correctly describes the complete combustion of octane in air is

- **A** $2C_8H_{18} + 9O_2 \rightarrow 16C + 18H_2O$.
- **B** $2C_8H_{18} + 17O_2 \rightarrow 16CO + 18H_2O$.
- **C** $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$.
- **D** $2C_8H_{18} + 34O_2 \rightarrow 16CO_2 + 18H_2O_2$.

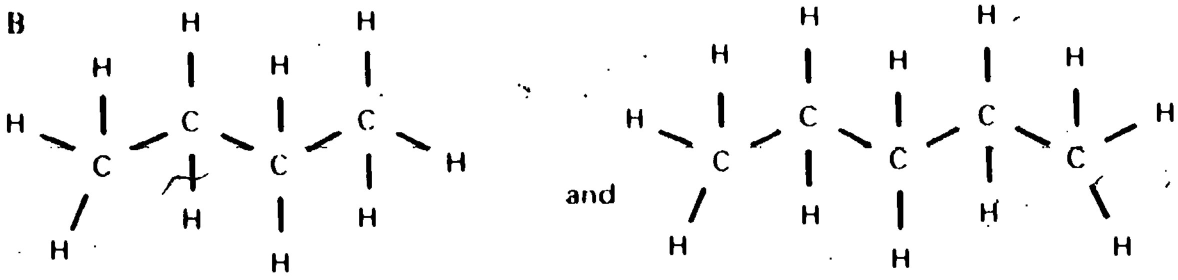
4.2(ii)

4-6 Which of the following pairs of molecular structures represent isomers?

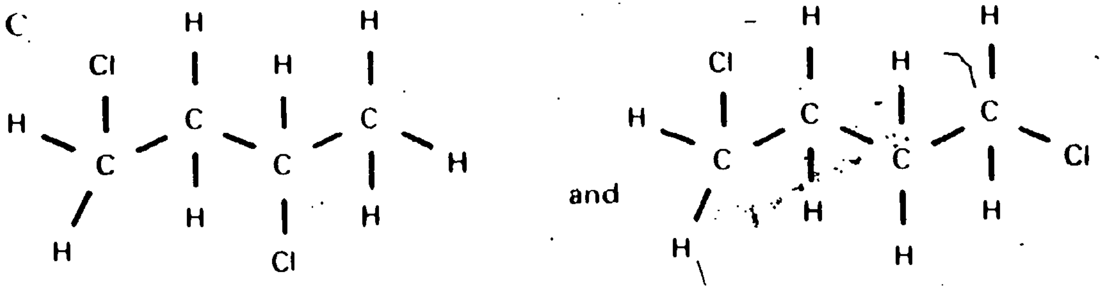
A



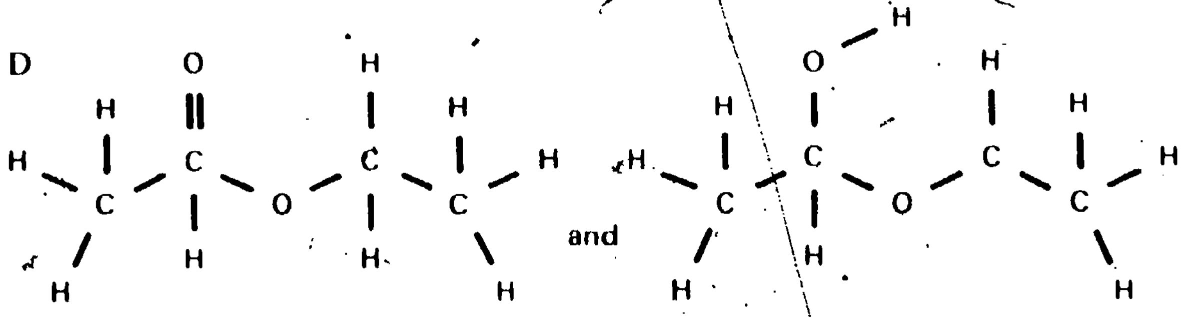
B



C



D



4.2(iii)

4-7 Which one of the following statements is consistent with the structure of silicon carbide?

- **A** It is covalently bonded because it is formed by subjecting carbon and silicon to very high temperatures.
- **B** It has strong covalent bonds in three dimensions.
- **C** It is a layer lattice with each atom covalently bonded to three other atoms.
- **D** Each carbon atom is covalently bonded to one other carbon atom.

4.2(iii) **4-8** The addition of powdered graphite to a lock which has been sticking will often cause the key to turn more easily.

Graphite has this effect because

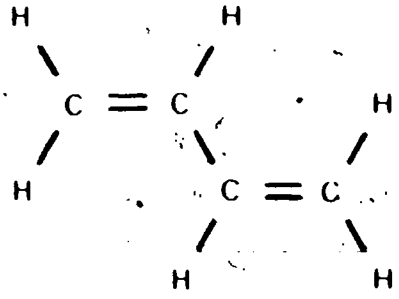
A each carbon atom has already formed four bonds, and hence can form an unreactive film over which metals can slide.

B its infinite lattice structure is very hard and strong, enabling moving parts to slide over a thin layer of graphite.

C the tetrahedral arrangement of bonds around each carbon atom causes neighbouring carbon atoms to slide past one another.

D the carbon atoms are bonded into two dimensional sheets which can slide freely over one another.

4.2(iii) **4-9** Butadiene — structural formula



is a reactive chemical used extensively in the production of synthetic rubber.

It is often described as an 'unsaturated' hydrocarbon because

A butadiene molecules are unstable and react easily.

B each butadiene molecule has two fewer hydrogen atoms than each butane molecule.

C each carbon atom in butadiene has only three shared electron pairs instead of four.

D each molecule of butadiene contains at least one double bond.

4.2(iv) **4-10** The vapour above a candle which has just been extinguished contains hydrocarbons which are gases at room temperature.

The process leading to the formation of these compounds is best described as

A distillation.

B vaporization.

C cracking.

D reforming.

4.2(iv) **4-11** Ethylene may be obtained from crude oil by

A separating out the lighter components by fractional distillation.

B separating out the heavier components by fractional distillation.

C catalytic cracking of the crude oil followed by distillation.

D catalytic reforming of the crude oil followed by distillation.

4.2(iv) **4-12** Ethylene reacts with water to produce ethanol according to the equation

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

This reaction is described as

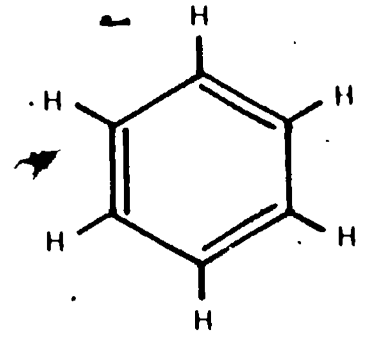
A a condensation reaction.

B a substitution reaction.

C an acid-base reaction.

D an addition reaction.

4.2(iv) **4-13** For many years chemists used the following structure to represent the benzene molecule



This structure is unsatisfactory because

A in some benzene molecules the double bonds are adjacent to one another.

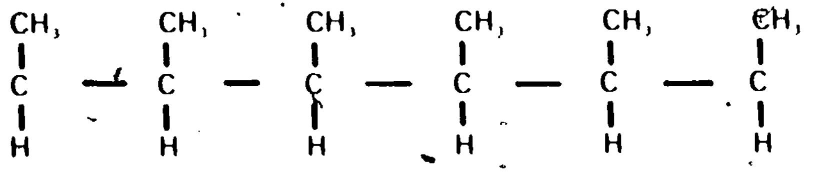
B each benzene molecule actually has six equivalent double bonds.

C two electrons from each double bond are actually shared with the other four carbon atoms.

D the carbon atoms are arranged in a circle, and not in a hexagon, as this structure suggests.

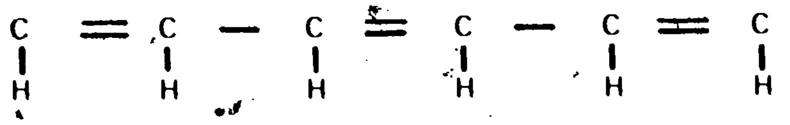
4.2(v) **4-14** Which one of the following structural formulae represents a segment of a polythene (poly(ethylene)) molecule?

A



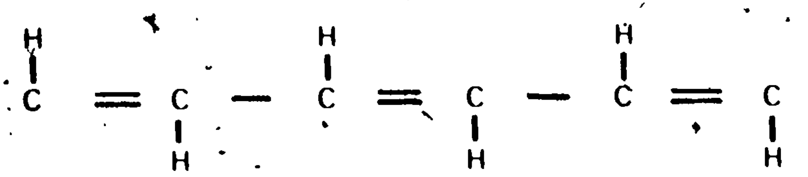
$$\cdots \overset{CH_3}{\underset{H}{C}} - \overset{CH_3}{\underset{H}{C}} - \overset{CH_3}{\underset{H}{C}} - \overset{CH_3}{\underset{H}{C}} - \overset{CH_3}{\underset{H}{C}} - \overset{CH_3}{\underset{H}{C}} \cdots$$

B



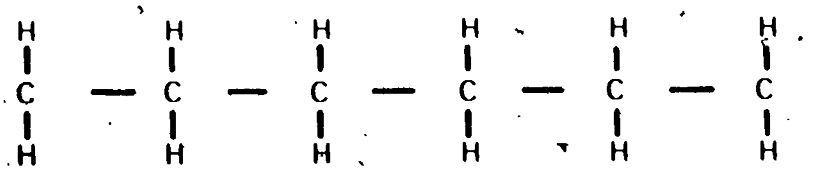
$$\cdots \underset{H}{C} = \underset{H}{C} - \underset{H}{C} = \underset{H}{C} - \underset{H}{C} = \underset{H}{C} \cdots$$

C



$$\cdots \overset{H}{C} = \underset{H}{C} - \overset{H}{C} = \underset{H}{C} - \overset{H}{C} = \underset{H}{C} \cdots$$

D



$$\cdots \overset{H}{\underset{H}{C}} - \overset{H}{\underset{H}{C}} - \overset{H}{\underset{H}{C}} - \overset{H}{\underset{H}{C}} - \overset{H}{\underset{H}{C}} - \overset{H}{\underset{H}{C}} \cdots$$

4.2(vi) **4-15** In the production of beer, yeast cells are added to a mixture of hops and barley. The purpose of the yeast is to

A convert sugar, derived from barley, into carbon dioxide and water, thus giving beer its effervescent nature.

B convert chemicals in hops into small proteins, giving beer a nutrient value.

C break down starch, from the barley, into glucose and carbon dioxide giving beer a high energy content.

D convert sugar, derived from barley, into ethanol, giving beer its alcoholic nature.

4.2(vi) **4-16** Which of the following **would not** be a source of carbon dioxide?

A fermentation of sugar to alcohols

B photosynthesis

C the production of calcium oxide from limestone

D the burning of fossil fuels

4-17 The molecule $CH_3CH(NH_2)COOH$ is an example of

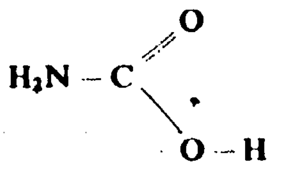
A a protein. 4.2(vi)
B an amino acid.
C a peptide.
D a nucleic acid.

4-18 A characteristic of enzymes is that

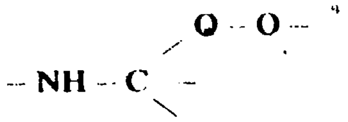
A they increase the rate of any chemical reaction in a living system. 4.2(vi)
B they are much more reactive than protein molecules.
C they function best in neutral solutions.
D they specifically catalyze particular chemical reactions.

4-19 The peptide link is the group of atoms which bond amino acids into proteins.
A structural representation of the peptide link is 4.2(vi)

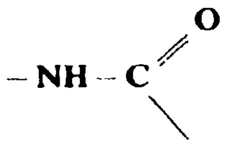
A



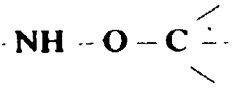
C



B



D



4-20 A biologist isolated a high molecular mass chemical from some living tissue. He found that it contained the elements carbon, nitrogen, hydrogen, and oxygen, that it was insoluble at high and low pH, and that it was made up of numerous sub-units. 4.2(vi)

Further investigations would probably show that

A the sub-units are identical.
B the sub-units are separable by hydrolysis.
C the sub-units are linked by carbon–carbon single bonds.
D the sub-units become negatively charged at low pH.

4-21 Which one of the following groups contains the formula of a substance which is unlikely to be found in large organisms?

A CO_2; O_2; $C_6H_{12}O_6$ 4.2(vi)
B H_2O; CO_2; $NaCl$
C CO_2; NH_3; SiO_2
D O_2; $(NH_2)_2CO$; H_2O

4-22 People intent on suicide may lock themselves in a confined space, and allow fumes from an internal combustion engine to fill the space. 4.2(vii)

High exhaust fume concentrations lead to death because

A carbon monoxide combines more extensively with haemoglobin than does oxygen, thus starving the tissues of oxygen.
B increased exhaust fume concentrations greatly lower the oxygen concentration in the air, causing death by asphyxiation.
C carbon dioxide dissolves in blood forming carbonic acid, causing death by acidosis.
D carbon monoxide and carbon dioxide dissolve more readily in blood than does oxygen, causing oxygen starvation in the tissues.

4-23 In which of the following processes does CO_2 **not** play an important role?

A photosynthesis 4.2(vii)
B combustion of hydrocarbons
C respiration
D petroleum refining

4.2(vii) **4-24** In order to make bread dough rise, a baker may use flour containing added chemicals. Which *one* of the following could be *satisfactorily* used by the baker?

A Na_2CO_3 **C** $CaCO_3$

B $NaHCO_3$ **D** $Ca(HCO_3)_2$

4.2(vii) **4-25** Most buildings constructed of quarried limestone show deterioration after a few years. A possible explanation of this phenomenon is that

A water reacts with calcium carbonate releasing carbon dioxide and leaving a deposit of brittle calcium hydrogen carbonate.

B carbon dioxide reacts with calcium oxide impurities in limestone, to produce reactive hydrogen carbonate ions.

C water combines with atmospheric carbon dioxide, forming carbonic acid, which, in turn, reacts with calcium carbonate to form soluble calcium hydrogen carbonate.

D water combines with calcium carbonate to form the strong base calcium hydroxide, which reacts with acidic impurities in the limestone.

4.2(vii) **4-26** Silane will burn spontaneously in air, yet methane has to be ignited. This difference can be attributed to

A Si–H bonds being stronger than C–H bonds and SiO_2 being more stable than CO_2.

B Si–H bonds being weaker than C–H bonds and SiO_2 being more stable than CO_2.

C Si–H bonds being stronger than C–H bonds and SiO_2 being less stable than CO_2.

D Si–H bonds being weaker than C–H bonds and SiO_2 being less stable than CO_2.

4.2(vii) **4-27** Silica (SiO_2) occurs naturally in three crystalline forms. Each of these forms

A has a crystal structure identical to each of the other forms.

B has the atoms arranged in a covalent network lattice.

C has physical properties identical to each of the other forms.

D has each silicon atom bonded to four oxygen atoms and vice versa.

4.2(vii) **4-28** Which of the following is **not** a property of glass?

A Glass softens gradually over a range of temperatures.

B The brittleness of glass is independent of the rate of cooling.

C Glass crystallizes only slowly at room temperature.

D Solid glass shows some of the properties of a liquid.

4.2(vii) **4-29** Clays are produced by

A the dissolving of silicate minerals in rain water.

B the weathering of sand grains containing silica.

C the reaction between silica-containing quartz and bicarbonate ion in the soil.

D the sticking together of small particles formed by the breakdown of silicate minerals.

4.2(vii) **4-30** In the manufacture of ceramics, the reason for the high firing temperature of the clay is to

A soften the mixture as a preparation for pouring into moulds.

B drive off the water of crystallization in order to increase the strength of the ionic bonding.

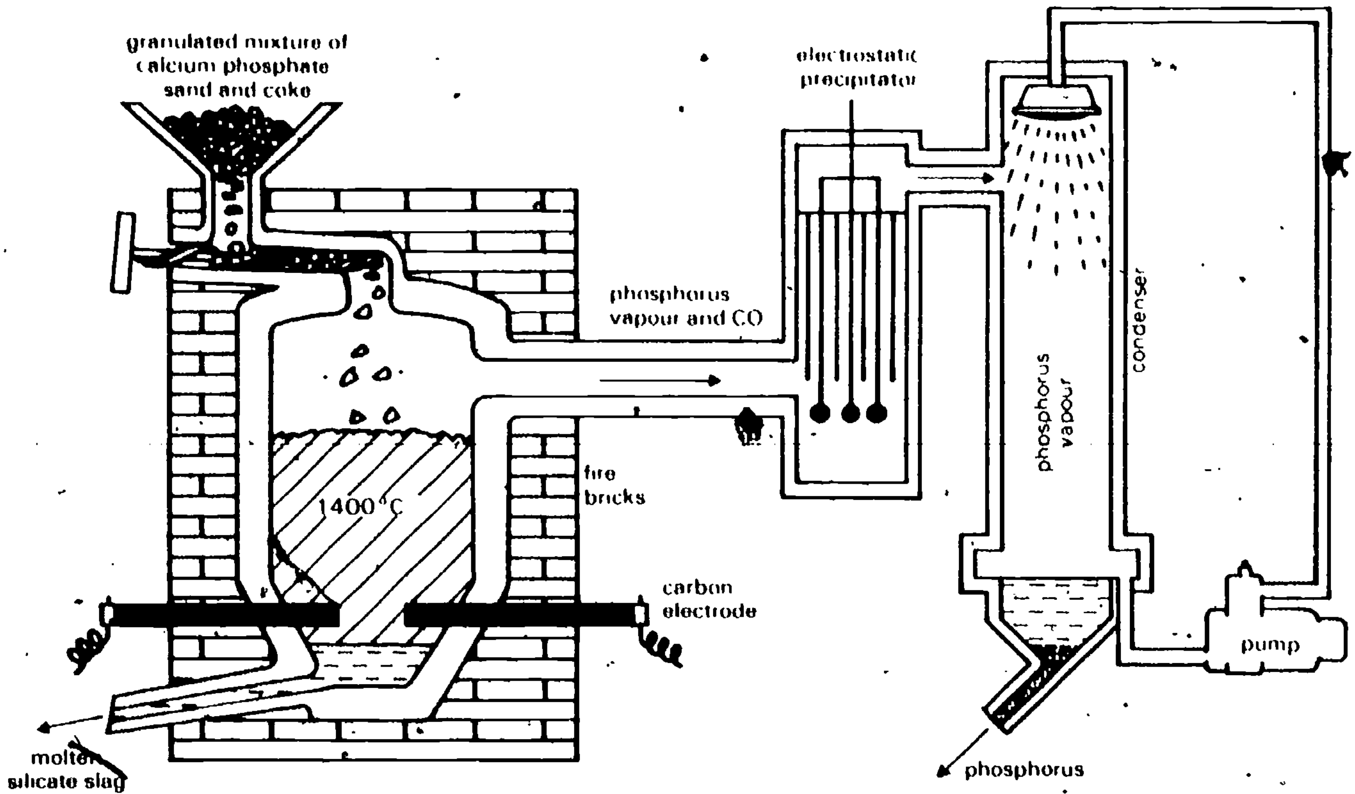
C increase the rate of particle diffusion, to ensure a regular crystal lattice.

D enable the particles present to fuse together to form a solid, coherent mass.

UNIT 5

4.3(i) The elements N, P
4.3(ii) Ammonia and phosphine
4.3(iii) Oxides of nitrogen and phosphorus
4.3(iv) The role of nitrogen and phosphorus in living systems

The next three items refer to the following diagram of a plant producing phosphorus.



5-1 The purpose of the coke is to

4.3(i) A oxidise PO_4^{3-} ions from calcium phosphate to P_4 molecules.

B oxidise SiO_2 from sand to SiO_3^{2-} ions.

C reduce P_4O_{10} molecules formed in the furnace to P_4 molecules.

D reduce atmospheric O_2 to CO, which acts as an inert atmosphere.

5-2 The purpose of the carbon electrodes is to

4.3(i) A reduce the PO_4^{3-} ions to P_4, and oxidise SiO_2 to SiO_3^{2-}.

B reduce PO_4^{3-} ions to P_4, and oxidise carbon to CO.

C electrostatically attract the molten silicate slag to the bottom.

D allow current to pass through the mixture, thereby generating heat.

5-3 The phosphorus is initially produced in the plant in the form(s) of

4.3(i) A	red phosphorus.	C	black phosphorus.
B	white phosphorus.	D	a mixture of more than one allotrope of phosphorus.

5-4 There are 3 main allotropes of phosphorus.

4.3(i) Which one of the following statements about the allotropes is correct?

A In each allotrope, the 15 electrons in each phosphorus atom are arranged in 3 orbitals.

B The chemical properties of each allotrope are identical, although the physical properties differ.

C In each allotrope, the phosphorus atoms have 5 valence electrons.

D The allotropes have different physical and chemical properties, although the arrangement of bonds within each allotrope is identical.

The Australian Council for Educational Research Limited, Radford House, Frederick Street, Hawthorn, Vic. 3122 · ACER CHEMTIC YEAR 12 — Unit 5

5-5 In which of the following compounds does phosphorus show the lowest oxidation state?

4.3(i) **A** PH_4Br **C** PF_3 **E** $Ca_3(PO_4)_2$

(2.2) **B** $POBr_3$ **D** PCl_5

5-6 Which **one or more** of the following statements describe(s) a role of atmospheric nitrogen?

4.3(i) **A** It is the immediate source of the nitrates required by plants.

B It is oxidised to NO_2 at the temperature of a lightning flash

C It prevents excessive rates of combustion in systems exposed to the atmosphere.

D It is converted to HNO_3 and NH_3 at the temperature of a lightning flash.

5-7 Atmospheric fixation of nitrogen occurs in lightning flashes according to the equation

4.3(ii)

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$

(2.4) For this reaction $K = 10^{-31}$ at 25 °C, and 5×10^{-3} at 3000 °C.

The differing K values indicate that

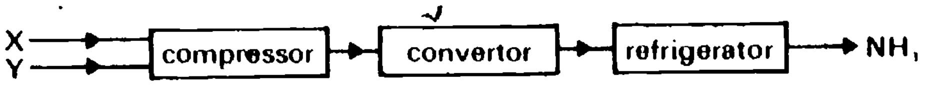
A the rate of NO formation is much greater at 3000 °C than at 25 °C.

B there will be a greater ratio of reactants to products at 3000 °C than at 25 °C.

C the reaction is exothermic.

D the decomposition of NO gives products with a heat content less than that of NO.

The next two items refer to the flow diagram below for the Haber Process.



5-8 The gases X and Y are

4.3(ii) **A** air and hydrogen. **C** air and nitrogen.

B hydrogen and nitrogen. **D** nitrogen and steam.

5-9 In the compressor, the pressure of the incoming gases is increased in order to

4.3(ii) **A** facilitate the dissociation of reactant molecules.

B increase the yield of ammonia being formed in the compressor.

C force the equilibrium position to the right for the reaction in the converter.

D eliminate the need for a catalyst.

5-10 The commercial production of ammonia is represented by the equation

4.3(ii)

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

(2.4) The reaction conditions may be adjusted so that

A increasing the temperature allows the forward reaction to proceed to a greater extent.

B lowering the pressure allows the forward reaction to proceed to a greater extent.

C any change in the rate of the forward reaction is compensated by an equal change to the rate of the back reaction.

D the rate of the forward reaction is fast enough to partially compensate for its small extent.

4.3(ii) **5-11** Ammonia has a boiling temperature of −33 °C.

The boiling temperature of phosphine (PH_3) will be

A higher than −33 °C, because phosphine molecules contain more electrons than ammonia molecules.

B lower than −33 °C, because the bond polarity in phosphine is much less than that in ammonia.

C higher than −33 °C, because the hydrogen bonds between phosphine molecules are stronger than those between ammonia molecules.

D lower than −33 °C, because P–H bonds are stronger than N–H bonds.

4.3(ii) **5-12** Which one of the following expressions will have the lowest equilibrium constant at room temperature and atmospheric pressure?

A $NH_3(g) + aq \rightleftharpoons NH_3(aq)$

B $NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

C $NH_3(aq) + H_2O(l) \rightleftharpoons NH_2^-(aq) + H_3O^+(aq)$

D $Ag^+(aq) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq)$

4.3(ii) **5-13** If a saturated solution of copper hydroxide in equilibrium with excess solid was maintained at a constant temperature, which of the following would cause additional copper hydroxide to dissolve?

A evaporation of half the water

B addition of solid $Cu(OH)_2$

C addition of solid NaOH

D addition of NH_3 solution

4.3(ii) **5-14** Silver chloride is virtually insoluble in water, yet significant amounts dissolve in 2 M ammonia solution.

The principle reaction involved in the dissolution of AgCl is

A the reaction of NH_4^+ ions with Cl^- ions to form soluble NH_4Cl.

B the removal of Ag^+ ions from solution as $Ag(OH)_2^-$ complex ions.

C the reaction of Ag^+ ions with OH^- ions to form soluble AgOH.

D the removal of Ag^+ ions from solution as $Ag(NH_3)_2^+$ complex ions.

4.3(iii) **5-15** Which of the following oxides of nitrogen cannot exist?

A NO_3 **B** NO **C** N_2O_5 **D** N_2O_4 **E** N_2O_3

4.3(iii) **5-16** Which one of the following oxides ~~does not~~ react with water to form an acidic solution?

A N_2O **B** N_2O_3 **C** N_2O_5 **D** P_4O_6 **E** P_4O_{10}

4.3(iii) **5-17** The acid anhydride of nitrous acid is

A N_2O. **B** N_2O_3. **C** N_2O_5. **D** HNO_3.

4.3(iii) **5-18** A student claimed that he had prepared a jar containing only NO_2 gas in his school laboratory, by reacting copper with concentrated nitric acid at room temperature.

His claim is likely to be incorrect because

A NO_2 is completely converted to NO at room temperature.

B NO_2 exists in an equilibrium mixture with N_2O_4, with the latter predominating at room temperature.

C NO_2 is present in an equilibrium mixture with NO, with the latter predominating at room temperature.

D NO_2 exists in an equilibrium mixture with N_2O, with the latter predominating at room temperature.

47

4.3(iii) **5-19** Which of the following species will be present in the greatest concentration when NO_2 is bubbled through cold water?

A $H_3O^+(aq)$ **B** $HNO_2(aq)$ **C** $NO_3(aq)$ **D** $HNO_3(aq)$

4.3(iii) **5-20** If a car engine was tuned to admit more air into the combustion chambers, then which of the following changes in the composition of the exhaust gases would be expected?

A NO_x emissions would be halted.

B The amount of unburnt hydrocarbon would increase.

C The amount of CO_2 would increase.

D The amount of CO would increase.

4.3(iii) **5-21** Which **one or more** of the following statements concerning the Ostwald Process is **incorrect**?

A The production of nitric acid from ammonia involves a process of oxidation.

B The conversion of ammonia to nitrogen oxide requires a catalyst.

C Nitrogen oxide is heated to a high temperature to speed up its conversion to nitrogen dioxide.

D The reaction of nitrogen dioxide with water produces a mixture of nitrous and nitric acids.

4.3(iii) **5-22** Addition of excess cold water to phosphorus (III) oxide produces

A a neutral solution. **C** H_3PO_3.

B H_3PO_4. **D** a mixture of H_3PO_3 and H_3PO_4.

4.3(iii) **5-23** Many chemical processes involve the use of a dehydrating agent – a chemical which absorbs water from its surroundings.

An example of the reaction of such a chemical is

A the conversion of P_4O_6 to P_4O_{10} and H_3PO_3, by reaction with water.

B the conversion of P_4O_{10} to H_3PO_3 and H_3PO_4, by reaction with water.

C the conversion of P_4O_{10} to H_3PO_4, by reaction with water.

D the conversion of P_4O_6 to H_3PO_4 by reaction with water.

4.3(iv) **5-24** Watson and Crick proposed a structure for the DNA molecule, consisting of two chains wrapped around each other in a double helix.

The two chains are held together by

A dispersion forces between adjacent bases.

B covalent bonds between adjacent bases.

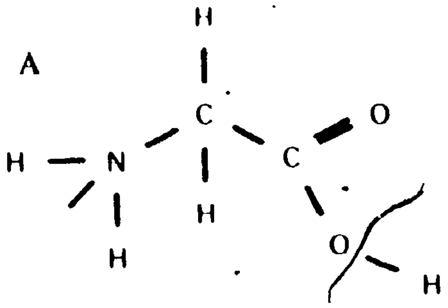
C hydrogen bonds between adjacent bases.

D peptide linkages between adjacent bases.

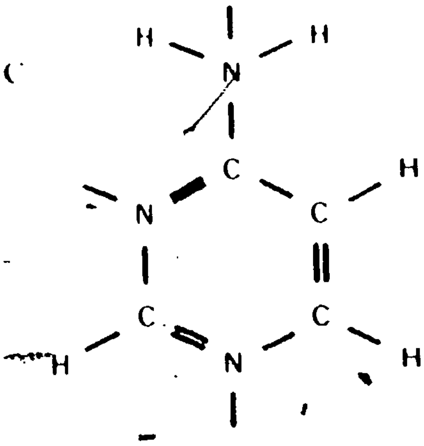
4.3(iv) **5-25** A build-up of nitrogen-containing waste products in the human body would lead to illness and eventual death.

Which of the following structures is most likely to represent a major human nitrogen-containing excretion product?

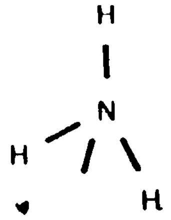
A



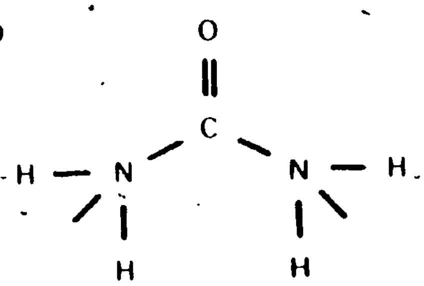
C



B



D



The following information refers to the next two items.

Part of the nitrogen cycle can be represented in the following way

$$\begin{tikzcd}
N_2 \arrow[r] & NO \arrow[d] \\
NO_3^- \arrow[u] & NO_2 \arrow[l]
\end{tikzcd}$$

4.3(iv) **5-26** Which one of the following phenomena could *not* be involved in this part of the cycle?

A the action of nitrogen fixing bacteria
B high temperature combustion
C electrical discharge
D the action of denitrifying bacteria

4.3(iv) (2.2) **5-27** Which of the following lists all the oxidation states shown by nitrogen in this part of the nitrogen cycle?

A −3; 0; +1; +3
B −3; +1; +2; +3
C 0; +2; +4; +5
D 0; +3; +4; +5

4.3(iv) **5-28** In which of the following ways do most plants obtain the nitrogen they require for their metabolic processes?

A by taking up nitrate ions from the soil, through the roots
B by taking up ammonium ions, produced by denitrifying bacteria, through the roots
C by absorbing, through the roots, amino acids from the remains of dead organisms
D by absorbing nitrogen directly from the atmosphere

4.3(iv) **5-29** Ammonium sulphate is used as a fertiliser because

A it acts as a source of NH_4^+ ions which can be used by plants as a source of nitrogen for amino acids.

B it aids in the eutrophication of soils.

C the NH_4^+ ions are easily oxidised to NO_3^- for incorporation into cellulose.

D it hydrolyses within the plant to provide a source of H_3O^+ ions for amino acid production.

4.3(iv) **5-30** After placing large amounts of fertilizer on a paddock, a farmer was surprised to find that the fish in an adjacent pond were dying.

The best explanation of this phenomenon is that

A the fertilizers act as a poison on fresh-water animals.

B the resulting rapid growth of fresh-water plants has removed most of the available oxygen from the pond.

C the subsequent growth of fresh-water plants has removed all the available minerals from the pond.

D the accumulation of nitrogenous compounds in solution renders the pond unfit for animal life.

UNIT 6

4.4(i)	Commercial sources of O, S, metals
4.4(ii)	The elements O, S;metals
4.4(iii)	Direct formation of oxides from metals
4.4(iva)	Oxides of sulfur; sulfuric acid
4.4(ivb)	Water
4.4(ivc)	Hydrogen peroxide

4.4(i) **6-1** Oxygen is obtained from liquid air by

- **A** catalytic oxidation.
- **B** fractional distillation.
- **C** catalytic cracking.
- **D** electrolytic decomposition.

4.4(i) **6-2** Metals are prepared commercially by extraction from their ores. A major constituent of a commercially extractable ore would be

A UF_6. **B** FeO. **C** $AgNO_3$. **D** PbS. **E** TiO_4.

4.4(i) **6-3** The alkaline earth metals occur naturally as

- **A** metal halides.
- **B** metal oxides.
- **C** metal sulfides.
- **D** free metals.

4.4(i) **6-4** In the blast furnace, iron oxides are reduced to metallic iron. The reducing agent is

- **A** air.
- **B** coke.
- **C** SiO_2.
- **D** limestone.
- **E** CO_2.
- **F** CO.

4.4(i) **6-5** Haematite is reduced in the blast furnace to iron metal. Successive oxides occurring in this process could be represented as

- **A** FeO, Fe_2O_3, Fe_3O_4.
- **B** Fe_3O_4, FeO, Fe_2O_3.
- **C** Fe_2O_3, FeO, Fe_3O_4.
- **D** Fe_2O_3, Fe_3O_4, FeO.

4.4(i) **6-6** Which of the following processes would not occur in a blast furnace?

- **A** Coke is added as a source of carbon monoxide.
- **B** Carbon monoxide reduces Fe_2O_3 to Fe.
- **C** Impurities in the ore combine with carbon monoxide to form a slag.
- **D** The molten pig iron collects at the **bottom** of the furnace.

4.4(i) **6-7** Copper that is 99% pure is produced by heating concentrated CuS ore with air in an electric furnace. Similar treatment of FeS ore generally yields an oxide rather than metallic iron. The **best** explanation of this is that

- **A** iron is more readily oxidized than copper, in air.
- **B** iron is more difficult to oxidize than copper, in air.
- **C** iron(II) is more difficult to reduce than copper(I).
- **D** iron(II) is more difficult to oxidize than copper(I).

4.4(i) **6-8** When a copper sulfide ore is roasted to produce copper, the major gaseous product of the roasting process is

A SO_3. **B** SO_2. **C** S_8. **D** CO. **E** CO_2.

4.4(i) **6-9** It is predicted that more energy is required per mole in the refining of molten alumina than in the refining of molten iron ore because

- **A** the refining of alumina is an electrochemical process, whereas that of iron ore is a thermal process.
- **B** alumina has a much higher melting temperature than iron ore.
- **C** alumina is more difficult to reduce to aluminium than iron oxide is to iron.
- **D** aluminium has a much higher melting temperature than iron.

4.4(i) **6-10** Which of the following is **not** a step in the industrial production of refined copper?

A the flotation of a copper ore

B the roasting of copper sulfide ores

C the heating of a mixture of copper oxide and coke in a furnace

D the electrolysis, using a copper anode, of an acidified copper sulfate solution

4.4(i) **6-11** In which of the following alternatives are metals listed in order of increasing **ease** of extraction from their ores?

A Fe, Al, Cu

B Al, Fe, Cu

C Al, Cu, Fe

D Cu, Al, Fe

E Cu, Fe, Al

4.4(i) (3.4) **6-12** In the refining of copper, the electrolyte used is acidified copper sulfate, whereas in the refining of aluminium the electrolyte is molten cryolite (Na_3AlF_6) in which alumina (Al_2O_3) has been dissolved.

The reason for the use of different electrolytes is that

A Al^{3+} ions do not dissolve in water, whereas Cu^{2+} ions do dissolve in water.

B Al^{3+} ions can only be reduced at high temperature, whereas Cu^{2+} ions are reduced at low temperatures.

C Al^{3+} ions are not reduced in aqueous solutions, whereas Cu^{2+} ions are reduced in aqueous solutions.

D Al^{3+} ions react to form $Al(H_2O)_6{}^{3+}$ complex ions in aqueous solution, whereas Cu^{2+} ions do not form similar complex ions.

4.4(ii) **6-13** Sulfur can exist in several structural forms at room temperature.

These forms are known as

A allotropes.

B homologues.

C isomers.

D isotopes.

4.4(ii) **6-14** An unusual property of sulfur is that, when it is heated beyond its melting temperature, its viscosity first increases before decreasing.

A possible explanation for this is that

A sulfur atoms are arranged in rings which become entangled at moderate temperatures.

B the increase in temperature causes the chains of sulfur atoms to break up; thus increasing the number of molecules present.

C as the temperature increases, the sulfur rings first break up to form long chains, which themselves break up on further heating.

D as the temperature increases, the sulfur chains form larger and larger rings, which gradually become entangled.

4.4(ii) **6-15** The set of elements which characteristically form coloured compounds and show a number of oxidation states are

A alkali metals.

B alkaline earth metals.

C metals occurring in period 3.

D transition metals.

4.4(ii) **6-16** Brass is an alloy formed by combining

A copper and tin.

B copper and zinc.

C zinc and tin.

D tin and lead.

E copper and lead.

4.4(ii) **6-17** Steel is an alloy of iron and carbon.

The reason that carbon is present in steels is to

A increase hardness and tensile strength.

B increase ductility and ability to be welded.

C increase electrical conductivity.

D reduce the rate of corrosion.

The following information refers to the next three items.

The underground pipeline bringing natural gas from Gippsland to Melbourne must pass through salty marshlands. Iron pipes are particularly susceptible to corrosion in the environment.

4.4(iii) **6-18** The overall corrosion reaction involves

A reduction of the iron.

B reaction of the iron with the dissolved salt.

C reaction of the iron with the dissolved oxygen.

D reaction of the iron with acid from dissolved carbon dioxide.

4.4(iii) **6-19** The corrosion process occurs in several steps.

Which of the following is **not** likely to be occurring as the iron corrodes?

A $Fe + O_2 + 2H_2O \rightarrow Fe^{2+} + 4OH^-$

B $4Fe^{2+} + O_2 + 2H_2O + 8OH^- \rightarrow 4Fe(OH)_3$

C $2Fe(OH)_3 \rightarrow Fe_2O_3.2H_2O + H_2O$

D $4Fe(OH)_3 \rightarrow 4Fe(OH)_2 + O_2 + 2H_2O$

4.4(iii) **6-20** By referring to the E^0 values below, select which one of the following methods would be least successful in reducing the corrosion of the iron.

$E^0_{Fe^{2+},Fe} = -0{\cdot}44\,V$; $E^0_{Cu^{2+},Cu} = +0{\cdot}34\,V$; $E^0_{Zn^{2+},Zn} = -0{\cdot}76\,V$

A completely plating the pipes with a coating of zinc

B attaching a piece of buried zinc metal to the pipe with an iron wire

C completely plating the pipes with a coating of copper

D attaching a piece of buried copper metal to the pipe with an iron wire

4.4(iii) **6-21** Freshly prepared aluminium filings react more vigorously with water than do freshly prepared iron filings, yet pots and pans are more likely to be made of aluminium than iron.

This is because

A aluminium is less likely to react than iron.

B iron rapidly forms an oxide coating, whereas aluminium forms such a coating only slowly.

C aluminium is covered by a uniform protective oxide film, whereas iron does not form such a uniform film.

D aluminium is not oxidized as rapidly, at high temperatures, as is iron.

4.4(iva) (2.2) **6-22** Which one of the following alternatives lists sulfur compounds in order of increasing oxidation number of sulfur?

A S; H_2S; SO_2; SO_3.

B S; SO_2; H_2SO_3; H_2SO_4.

C H_2S; S; SO_2; H_2SO_3.

D H_2S; S; SO_2; SO_3.

4.4(iva) **6-23** The 'contact' process is the major source of the world's sulfuric acid.

Which of the following events would take place in industrial plants using this process?

A Oxygen is bubbled through liquid sulfur in the converter to form sulfur dioxide.

B Sulfur dioxide and oxygen are reacted catalytically to form sulfur trioxide.

C Sulfur trioxide and water are reacted catalytically to produce sulfuric acid.

D Pure sulfuric acid is separated from the water by fractional distillation.

4.4(iva) **6-24** High concentrations of SO_2 have been blamed for the increased mortality rates occurring in times of 'smog'.

Which of the following processes would **not** release SO_2 into the atmosphere?

- **A** the action of water on superphosphate fertilisers
- **B** the combustion of naturally occurring hydrocarbons
- **C** the oxidation of sulfide ores in a smelter
- **D** the emission of gases from a plant using the 'contact' process

4.4(iva) (2.4) **6-25** One of the reactions involved in the production of H_2SO_4 is given by the following equation.

$$SO_2(g) + \tfrac{1}{2}O_2(g) \rightarrow SO_3(g) \qquad \Delta H \quad 380\ \text{kJ mol}^{-1}$$

In industrial plants, this reaction takes place at moderately high temperatures, because

- **A** the equilibrium constant is too low at low temperatures.
- **B** SO_2 is a liquid at room temperature.
- **C** the rate of reaction is low at room temperature.
- **D** the SO_2 used is already at a high temperature from the previous reaction.

4.4(iva) **6-26** Which of the following could **not** be produced if sulfuric acid were added to a reactive metal?

A S **B** SO_3 **C** SO_2 **D** H_2S

4.4(iva) **6-27** A feature of the reaction between sulfuric acid and glucose is that

- **A** each sulfuric acid molecule donates protons to a glucose molecule.
- **B** each glucose molecule is rapidly oxidised by sulfuric acid to carbon dioxide and water.
- **C** sulfuric acid extracts hydrogen and oxygen from glucose leaving only carbon.
- **D** the heat evolved in this exothermic reaction causes the combustion of the glucose.

4.4(ivb) **6-28** The water molecules in ice are essentially bonded to each other by attractions between

- **A** instantaneous dipoles within each water molecule.
- **B** instantaneous ion-dipole interactions formed between adjacent water molecules.
- **C** permanent dipoles within each water molecule.
- **D** permanent ion-dipole interactions formed between adjacent water molecules.

4.4(ivb) **6-29** Despite the fact that the molar mass of H_2S is approximately double that of H_2O, H_2S has a boiling temperature of −62 °C, while that of H_2O is 100 °C under the same pressure.

This apparent anomaly is due to

- **A** the weakly acidic nature of H_2O compared to H_2S.
- **B** the greater reactivity of H_2S compared to H_2O.
- **C** the stronger attraction between hydrogen atoms in H_2O compared with H_2S.
- **D** the existence of stronger dipoles in liquid H_2O than in liquid H_2S.

4.4(ivc) **6-30** Hydrogen peroxide is often used as a bleaching agent—for example, it may be used to lighten the colour of hair.

In such a reaction, the H_2O_2

- **A** reacts with natural body acids to produce O_2 and OH^-.
- **B** reacts with oxidants present in hair to produce O_2.
- **C** is reduced to H_2O by chemicals present in hair.
- **D** catalyses the breakdown of pigment molecules present in hair.

UNIT 7
ACHIEVEMENT TEST

1.1	The nuclear atom
1.2	Electronic structure of atoms
1.3	The periodic table
2.1	The mole and chemical formulae
2.2	Chemical reactions
2.3	Stoichiometric calculations
2.4	Chemical equilibrium
3.2	Transformation of energy by chemical reaction
3.3	Production of electrical energy by chemical reaction
3.4	Chemical reactions driven by electrical energy
4.2(i)	The elements C, Si
4.2(ii)	Hydrides of C, Si
4.2(iii)	Covalent bonding in compounds of C and Si
4.2(iv)	Chemistry of some oil and coal derivatives
4.2(v)	Polymers
4.2(vi)	Some molecules of biological importance
4.2(vii)	Oxides of C, Si
4.3(i)	The elements N, P
4.3(ii)	Ammonia and phosphine
4.3(iii)	Oxides of nitrogen and phosphorus
4.3(iv)	The role of nitrogen and phosphorus in living systems
4.4(i)	Commercial sources of O, S, metals
4.4(ii)	The elements O, S; metals
4.4(iii)	Direct formation of oxides from metals
4.4(iva)	Oxides of sulfur; sulfuric acid
4.4(ivb)	Water
4.4(ivc)	Hydrogen peroxide

1.1 **7-1** One of the nuclear reactions studied by Lord Rutherford was the bombardment of nitrogen nuclei by alpha-particles. The reaction can be represented as

$$^{14}_{7}N + ^{4}_{2}He \to ^{13}_{6}C + ^{1}_{1}H + X$$

The particle X is,

A an electron.

B a proton.

C an alpha-particle.

D a deuterium nucleus.

1.1 **7-2** As a result of the nuclear fusion process occurring in the sun,

A the average mass of the nuclei in the sun is increasing.

B the sun is becoming heavier.

C the number of nuclei in the sun is increasing.

D the number of $^{1}_{1}H$ nuclei in the sun is increasing.

1.1 **7-3** The hydrogen bomb makes use of the following reaction

$$4\,^{1}_{1}H \to ^{4}_{2}He + 2e^{+}$$

1 mol of $^{1}_{1}H$ atoms has mass $1 \cdot 007825 \times 10^{-3}$ kg.

1 mol of $^{4}_{2}He$ atoms has mass $4 \cdot 002604 \times 10^{-3}$ kg.

1 mol of e^{+} particles has mass $0 \cdot 0005486 \times 10^{-3}$ kg.

c represents the velocity of light, in appropriate units.

When 4 mol of $^{1}_{1}H$ atoms react in this manner, the energy released is

A $10^{-3}(4 \cdot 002604 + 0 \cdot 0005486 - 1 \cdot 007825)c$ Joule.

B $10^{-3}(4 \cdot 002604 + (2 \times 0 \cdot 0005486) - (4 \times 1 \cdot 007825))c^2$ Joule.

C $10^{-3}((4 \times 1 \cdot 007825) - (2 \times 0 \cdot 0005486) - 4 \cdot 002604)c^2$ Joule.

D $10^{-3}(4 \cdot 002604 + 0 \cdot 0005486 - (4 \times 1 \cdot 007825))c$ Joule.

1.2 **7-4** The element vanadium has the following electronic configuration:

$$1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$$

A feature of this element is that it

A contradicts the Pauli principle, as the d-orbital contains 3 electrons.

B has electrons in only four different sub-shells.

C has a full outer shell of electrons.

D has two partially filled electron shells.

1.3 **7-5** An element has an atomic number of 33. The element will be located in the periodic table in

A group III, period 3.

B group IV, period 5.

C group V, period 4.

D the first transition series.

2.1 **7-6** The mass of nitrogen gas ($M_r = 28 \cdot 0$) which must be mixed with 12 g of oxygen gas ($M_r = 32 \cdot 0$) so that $5 \cdot 6$ dm³ of the resulting gas mixture will contain equal numbers of molecules of each gas is

A $\dfrac{5 \cdot 6 \times 12 \times 28 \cdot 0}{22 \cdot 4 \times 32 \cdot 0}$ g.

B $\dfrac{22 \cdot 4 \times 12 \times 28 \cdot 0}{5 \cdot 6 \times 32 \cdot 0}$ g.

C $\dfrac{12 \times 28 \cdot 0}{32 \cdot 0}$ g.

D $\dfrac{12 \times 32 \cdot 0}{28 \cdot 0}$ g.

2.1 **7-7** The following statements refer to equal masses of gaseous dinitrogen pentoxide, N_2O_5, and gaseous dinitrogen tetroxide, N_2O_4, confined to equal volumes at the same temperature. Assume that neither gas decomposes appreciably at this temperature. (A_r N 14; O 16)

Select which one of the statements is correct.

A The two gases will exert the same pressure.
B N_2O_5 will exert the higher pressure.
C N_2O_4 will exert the higher pressure.
D There is insufficient data to allow the calculation of the relative pressures.

2.2 **7-8** The equation for the following reaction, which occurs in acidic solution, has been left unbalanced.

$$\_MnO_4^- + \_SO_3^{2-} + \_H_3O^+ \rightarrow Mn^{2+} + H_2O + \_SO_4^{2-}$$

Coefficients for MnO_4^- and SO_3^{2-} which balance the equation are, respectively,

A 1 and 6. **B** 2 and 5. **C** 3 and 4. **D** 4 and 3. **E** 5 and 2.

2.3 **7-9** Assuming precipitation is complete, the mass of $Fe(OH)_3$ (M_r = 107) obtained when 9·0 cm^3 of 0·10 M NaOH solution is added to 500 cm^3 of 1·00 M $FeCl_3$ solution is

A $\dfrac{9 \times 0{\cdot}1 \times 107}{1000}$ g. **C** $\dfrac{3 \times 9 \times 0{\cdot}1 \times 107}{100}$ g.

B $\dfrac{9 \times 0{\cdot}1 \times 107}{1000 \times 3}$ g. **D** $\dfrac{3 \times 0{\cdot}1 \times 107}{1000 \times 9}$ g.

2.3 **7-10** Student A standardized a sodium hydroxide solution by titrating a hydrochloric acid solution of accurately known molarity against it, with phenolphthalein as the indicator. He obtained an average titre of 18·90 cm^3 for his HCl solution.

Student B, using the same solutions, obtained an average titre of 19·35 cm^3.

A possible cause of this difference could be

A Student A's failure to dry the flask into which the solution was titrated.
B Student A's failure to remove traces of water from the burette by first rinsing it with the acid solution.
C Student B's failure to dry the flask into which the solution was titrated.
D Student B's failure to remove traces of water from the burette by first rinsing it with the acid solution.

2.3 **7-11** 6·834 g of hydrated iron (II) sulfate $FeSO_4.7H_2O$ was weighed out, transferred to a standard flask, acidified with sulfuric acid and made up to 250 cm^3. A 25 cm^3 aliquot of this solution was transferred by pipette to a conical flask and titrated against some previously standardized potassium permanganate solution. On the basis of the mass of salt taken and the known value of the molarity of the permanganate, a titre of 23·10 cm^3 was expected. In fact the titre was 22·13 cm^3.

Which is the best explanation for this difference between observed and expected values?

A The iron (II) sulfate was partially dehydrated before weighing.
B The iron (II) sulfate was partially oxidized.
C Between the time of standardization and its use in the titration, the potassium permanganate had become partially reduced to manganese dioxide, which precipitated from solution.
D The potassium permanganate had become diluted, possibly due to water in the burette.
E Too much sulfuric acid had been added to the iron (II) sulfate.

7-12 When $Cr(NO_3)_3$ is added to water the Cr^{3+} ions react according to the equation

2.3 $$Cr^{3+} + 6H_2O \rightarrow Cr(H_2O)_6^{3+}$$

The hydrated Cr^{3+} ions then react with water according to the equation

$$Cr(H_2O)_6^{3+} + H_2O \rightleftharpoons [Cr(H_2O)_5OH]^{2+} + H_3O^+$$

The pH of a 0·1 M solution of $Cr(NO_3)_3$ is 3.

Assuming that the H_3O^+ ion in the solution is obtained only from this reaction, then the percentage of the $Cr(H_2O)_6^{3+}$ ion that has reacted with the water is

A 1 %. **C** 30 %.

B 10 %. **D** impossible to determine from the information given.

7-13 Equilibrium is established rapidly at 500 °C for the exothermic reaction

2.4 $$X(s) + Y(g) \rightleftharpoons Z(s)$$

However, the yield of Z is low.

In order to increase the yield of Z, which one of the following modifications should **not** be used?

A raising the temperature to 700 °C **C** raising the pressure

B using a suitable catalyst **D** using a more finely powdered form of X

The following information refers to the next three items.

At room temperature, nitrogen dioxide, NO_2, exists in an equilibrium with dinitrogen tetroxide, N_2O_4. NO_2 is brown, N_2O_4 is colourless.

An estimate of the relative amounts of NO_2 and N_2O_4 present in two samples can be obtained by comparison of the intensities of the brown colour in each sample. In a particular experiment, equal samples of the above equilibrium mixture were placed into two glass capsules, fitted with taps, at room temperature and atmospheric pressure.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -58{\cdot}2\ kJ\ mol^{-1}$$

7-14 When one of the capsules is immersed in cold water, the intensity of the brown colour in this
2.4 sample

A increases. **C** remains the same.

B decreases. **D** cannot be predicted.

7-15 The tap of this cooled capsule is opened to the air for a fraction of a second, allowing a small
2.4 amount of air to enter.

The intensity of the brown colour in this capsule, relative to the other sample which is still at room temperature is now

A greater than in the second capsule. **C** the same as in the second capsule.

B less than in the second capsule. **D** unable to be predicted.

7-16 The cooled mixture is now returned to room temperature without opening the tap again.
2.4 The intensity of the brown colour in this capsule compared to the unaltered sample is

A much greater. **C** approximately the same.

B much less. **D** unable to be predicted.

7-17 How much heat is evolved when 13 g of acetylene (C_2H_2) is burnt in air according to the equation

3.2 $$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(l) \qquad \Delta H = -2610\ kJ \quad (A_r\ C = 12,\ H = 1)?$$

A 652·5 kJ **C** 2610 kJ

B 1305 kJ **D** 5220 kJ

7-18 0·5 mol of CO and 0·4 mol of O_2 were placed in a sealed vessel and the temperature was held constant until equilibrium was attained according to the equation 3.2

$$2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g) \qquad \Delta H \qquad 564 \text{ kJ mol}^{-1}$$

If 0·3 mol of O_2 remains at equilibrium, the thermal energy released would be

A 0·1 × 564 kJ

B 0·2 × 564 kJ

C 0·3 × 564 kJ

D 0·4 × 564 kJ

7-19 When solid sodium nitrate is dissolved in pure water, the reaction may be represented by the equation 3.2

$$NaNO_3(s) + aq \rightarrow Na^+(aq) + NO_3^-(aq) \qquad \Delta H = +21 \text{ kJ mol}^{-1}$$

0·01 mole of solid $NaNO_3$ is dissolved in 100 cm^3 of pure water.

The quantity of heat that would need to be absorbed from the surroundings, in order to return the solution to the original temperature, is

A $2 \cdot 1 \times 10^{-2}$ kJ.

B $2 \cdot 1 \times 10^{-1}$ kJ.

C $2 \cdot 1 \times 10^{0}$ kJ.

D $2 \cdot 1 \times 10^{1}$ kJ.

E $2 \cdot 1 \times 10^{2}$ kJ.

7-20 The overall reaction for a lead-acid accumulator is 3.3

$$Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l).$$

Given the following data:

$$PbO_2(s) + 4H^+(aq) + 2e^- \rightarrow Pb^{2+}(aq) + 2H_2O(l) \qquad E^0 = 1 \cdot 46 \text{ V}$$

$$PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l) \qquad E^0 = 1 \cdot 69 \text{ V}$$

$$PbSO_4(s) + 2e^- \rightarrow Pb(s) + SO_4^{2-}(aq) \qquad E^0 = -0 \cdot 36 \text{ V}$$

$$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s) \qquad E^0 = -0 \cdot 13 \text{ V}$$

then the approximate potential that could be expected from the cell is

A 1·33 V.

B 1·59 V.

C 1·82 V.

D 2·05 V.

The next two items refer to the following information.

Two cells are connected as shown in the diagram below.

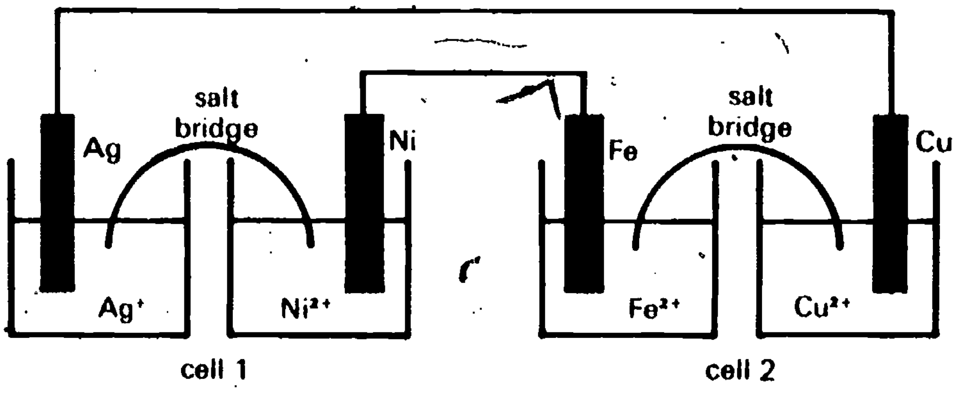
$$[Ag^+] = [Ni^{2+}] = [Fe^{2+}] = [Cu^{2+}] = 1 \text{ M}$$

$$Ag^+ + e^- \rightarrow Ag \qquad E^0 = 0 \cdot 80 \text{ V}$$

$$Cu^{2+} + 2e^- \rightarrow Cu \qquad E^0 = 0 \cdot 34 \text{ V}$$

$$Ni^{2+} + 2e^- \rightarrow Ni \qquad E^0 = -0 \cdot 23 \text{ V}$$

$$Fe^{2+} + 2e^- \rightarrow Fe \qquad E^0 = -0 \cdot 41 \text{ V}$$



7-21 Which of the following statements **best** describes the processes occurring in the two cells? 3.3

A Cell 1 behaves as an electrochemical cell, and electrolysis occurs in cell 2.

B Cell 2 behaves as an electrochemical cell, and electrolysis occurs in cell 1.

C Both cells 1 and 2 behave as electrochemical cells.

D Electrolysis occurs in both cells 1 and 2.

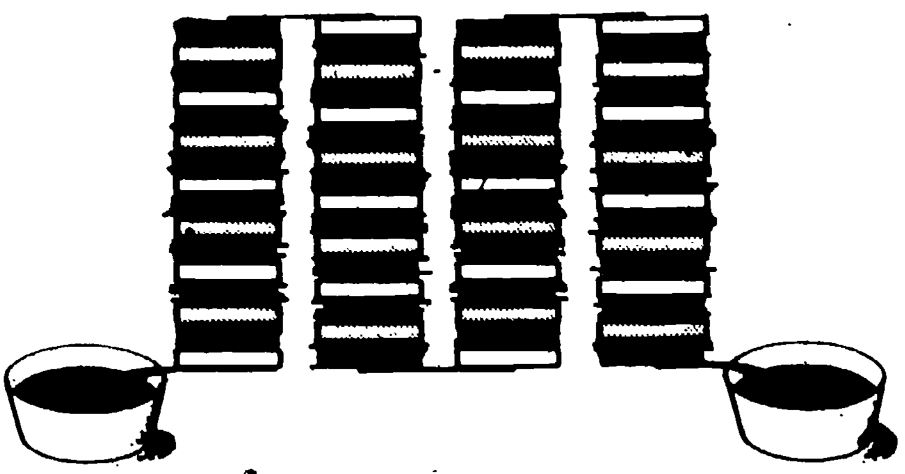
E No reaction will occur in either cell.

The Australian Council for Educational Research Limited, Radford House, Frederick Street, Hawthorn, Vic 3122 — ACER CHEMTIC YEAR 12 — Unit 7.

3.3 **7-22** If a voltmeter is added to the circuit, the resultant potential of the two cells as connected in the diagram above is

A 1·03 V. **B** 0·75 V. **C** 1·78 V. **D** 0·28 V.

3.3 **7-23** The diagram at right is a representation of Volta's first practical battery. It consisted of columns of alternating zinc and copper plates separated by layers of blotting paper soaked in salt solution.



$E^0_{Cu^{2+},Cu}$ 0·34 V; $E^0_{H^+,H_2}$ 0·0 V

$E^0_{Sn^{2+},Sn} = -0·14$ V; $E^0_{Zn^{2+},Zn} = -0·76$ V

In such a battery

A the zinc plates would be consumed in the reaction.
B if tin was substituted for zinc, there would be little change in the power of the battery.
C the blotting paper acts as a salt bridge allowing charge to flow from one plate to another.
D the copper plates would increase in mass during the reaction.

3.4 **7-24** In the electrolysis of a very dilute solution of lithium chloride, using a potential difference of 5 V,

A hydrogen is produced at the cathode, and oxygen is produced at the anode.
B hydrogen is produced at the cathode, and chlorine is produced at the anode.
C lithium is produced at the cathode, and chlorine is produced at the anode.
D chlorine is produced at the cathode, and hydrogen is produced at the anode.
E oxygen is produced at the cathode, and hydrogen is produced at the anode.

4.2(ii) **7-25** Which one of the following groups of formulae would represent members of a homologous series?

A CH_3Cl; CH_2Cl_2; $CHCl_3$; CCl_4
B CH_2CH_2; $CH_2CH_2CH_2$; $CH_2CH_2CH_2CH_2$; $CH_2CH_2CH_2CH_2CH_2$
C CH_4; CH_3CH_3; $CH_3CH_2CH_3$; $CH_3CH_2CH_2CH_3$
D CH_4; CH_3Cl; CH_3OH; HCHO

4.2(iii) **7-26** Which one of the following displays a structure markedly different from the other four?

A diamond **C** silicon **E** silica
B graphite **D** silicon carbide

4.2(iv) (2.3) **7-27** 250 cm³ of gaseous benzene is to be completely hydrogenated to cyclohexane (C_6H_{12}). If the volume of hydrogen required is measured under the same conditions of temperature and pressure, it will be

A 125 cm³. **B** 250 cm³. **C** 500 cm³. **D** 750 cm³.

4.2(iv) **7-28** Crude oil contains a high proportion of hydrocarbons with a molecular mass of over 150, and yet most products of the petroleum industry have a molecular mass which is less than this.

The **formation** of these low relative molecular mass compounds is best achieved by

A heating the crude oil slowly, and collecting the various liquids as they evaporate.

B heating the crude oil, in the presence of a catalyst, to 500 °C for 10 minutes to shorten the average chain length.

C heating the crude oil, in the presence of a catalyst and hydrogen gas, to 140 °C, to saturate all double bonds present.

D burning the crude oil in an oxygen rich environment, and collecting and liquefying the evolved gases.

4.2(v) **7-29** 'Fluon' is the trade name given to a high molecular mass chemical, used as a non-stick coating on kitchenware. It is formed by the reaction, in the presence of a catalyst, of tetrafluoroethylene molecules.

In this process

A an addition reaction takes place, with the elimination of water molecules.

B an addition reaction takes place, producing only the polymer and no other products.

C a condensation reaction takes place, with the elimination of water molecules.

D a condensation reaction takes place, producing only the polymer and no other products.

4.2(vi) **7-30** Which one of the following statements does **not** describe a reaction of glucose?

A Glucose reacts with oxygen exothermically to produce carbon dioxide and water.

B Glucose molecules react exothermically to produce cellulose and water.

C Glucose reacts exothermically to produce carbon dioxide and ethanol.

D Glucose molecules react endothermically to produce starch and water.

4.2(vi) **7-31** The amino acid glycine may exist in aqueous solution in several forms.

Which of the following would be the major component in strongly basic solution?

A NH_2-CH_2-COOH **C** $NH_2-CH_2-COO^-$

B $NH_3^+-CH_2-COOH$ **D** $NH_3^+-CH_2-COO^-$

4.2(vii) **7-32** When oxygen is given to patients suffering from carbon monoxide poisoning, it

A has a greater affinity for haemoglobin than does CO, and hence CO is removed from the bloodstream.

B oxidizes CO in the blood to CO_2.

C shifts the equilibrium in the reaction O_2 + haemoglobin/CO $\rightleftharpoons$ haemoglobin/O_2 + CO, to the right.

D increases the concentration of O_2 dissolved in the blood, and hence lowers the concentration of CO in the blood.

4.2(vii) **7-33** Marble statues in the open air often show signs of chemical weathering after a number of years.

The most likely explanation for this is that

A the calcium hydrogen carbonate in the marble reacts with dissolved CO_2 in rain water.

B H_3O^+ ions present in rain water react with the CO_3^{2-} ions present in the marble.

C the HCO_3^- ion undergoes both acid and base hydrolysis in the presence of water.

D the insoluble CO_3^{2-} ions are oxidized by dissolved O_2 to soluble HCO_3^- ions.

4.2(vii) **7-34** Which one (or more) of the following properties is (are) important in the use of clays for the manufacture of ceramics?

- **A** When heated strongly, the particles fuse together, forming a hard non-plastic product.
- **B** Strong heating results in a molecular rearrangement within the particles, resulting in a shiny appearance.
- **C** When moist, clays have plastic properties.
- **D** When dried, clays become rigid.

4.3(i) **7-35** The allotropes of phosphorus, from most reactive to least reactive are

- **A** red, black, white.
- **B** red, white, black.
- **C** white, red, black.
- **D** white, black, red.
- **E** black, red, white.
- **F** black, white, red.

4.3(ii) **7-36** Silver chloride reacts with an aqueous ammonia solution.

The equation which best describes this reaction is

- **A** $AgCl(s) + 2NH_3(aq) \rightarrow NH_4Cl(aq) + AgNH_2(s)$
- **B** $AgCl(s) + NH_3(aq) \rightarrow HCl(aq) + AgNH_2(s)$
- **C** $AgCl(s) + 2NH_3(aq) \rightarrow Ag(NH_3)_2^+(aq) + Cl^-(aq)$
- **D** $AgCl(s) + 2NH_3(aq) + 2H_2O(l) \rightarrow Ag(NH_4)_2^{3+}(aq) + Cl^-(aq) + 2OH^-(aq)$

4.3(ii) **7-37** The preparation of ammonia from its elements is an exothermic process. Conditions to obtain a favourable equilibrium yield in this reaction would be

- **A** high temperatures and high pressures.
- **B** low temperatures and high pressures.
- **C** low temperatures and low pressures.
- **D** high temperatures and low pressures.

4.3(iii) **7-38** Some chemicals produced by the internal combustion engine are a major source of pollution. These chemicals include

- **A** NO_2 produced by the reaction of atmospheric nitrogen with oxygen at high temperatures.
- **B** NO produced by the reaction of atmospheric nitrogen with oxygen at high temperatures.
- **C** NO_2 produced by the reaction of nitrogen impurities in the fuel with oxygen at high temperatures.
- **D** NO produced by the reaction of nitrogen impurities in the fuel with oxygen at high temperatures.

4.3(iii) **7-39** Nitric acid production from ammonia is a multi-step operation, in which the reaction conditions are carefully chosen.

A condition which would **not** lead to a high yield of nitric acid involves

- **A** the use of a catalyst to favour the production of NO, and not N_2 from the combustion of NH_3.
- **B** a temperature sufficiently high to result in a high yield of NO, but not high enough to cause breakdown of NO to N_2 and O_2.
- **C** a temperature sufficiently high to prevent N_2O_4 production from the oxidation of NO.
- **D** the decomposition of any HNO_2 produced to NO and NO_2 which can be re-oxidised.

4.4(i) **7-40** The stages in the industrial production of copper are, in order,

- **A** flotation; roasting; electrolysis.
- **B** roasting; electrolysis; flotation.
- **C** electrolysis; roasting; flotation.
- **D** roasting; flotation; electrolysis.

4.4(ii) **7-41** Transition metals can be distinguished from main group metals by the fact that

- **A** main group metals, but not transition metals, must have a valency of +1 or +2.
- **B** main group metals have lower relative atomic masses than transition metals.
- **C** transition metals, but not main group metals, can form complex ions.
- **D** transition metals have a greater tendency to form coloured salts than main group metals.

4.4(iii) **7-42** Zinc blocks buried in the soil are often attached at regular intervals to steel pipe lines. The purpose of the zinc blocks is to

A reduce the Fe^{2+} ions formed to Fe.

B be oxidized preferentially before the Fe.

C promote formation of a protective film of Fe_2O_3 on the pipe line.

D preferentially react with any reducing agent near the pipe line.

4.4(iii) **7-43** Steel will corrode in the presence of oxygen and water, unless precautionary measures are taken. Which one of the following does **not** occur in the formation of rust in a **damp** environment?

A the oxidation of Fe to Fe^{2+} with the corresponding reduction of oxygen to OH

B the oxidation of Fe^{2+} to Fe^{3+} by reaction with water and oxygen

C the formation of $Fe(OH)_3$

D the dehydration of $Fe(OH)_3$ to Fe_2O_3 .

4.4(ivb) **7-44** Water and hydrogen sulfide differ in that

A the H_2S molecule is linear, whereas the H_2O molecule is V-shaped.

B H_2S shows acidic properties whereas H_2O does not.

C H_2O molecules can be linked by hydrogen bonds, whereas H_2S molecules cannot be linked in this manner.

D H_2S can be oxidized to S whereas H_2O cannot be oxidized to O_2.

4.4(ivc) **7-45** Which **one** of the following statements **best** describes the behaviour of H_2O_2? It can be

A oxidized to H_2O or reduced to O_2.

B oxidized to O_2 or reduced to H_2O.

C oxidized to H_2O but does not undergo reduction.

D oxidized to O_2 or reduced to H_2.