DOCUMENT RESUME

ED 425 920 SE 061 922

TITLE	Chemistry 30 Diploma Examination Results. Examiners' Report for June 1998.
INSTITUTION	Alberta Dept. of Education, Edmonton. Student Evaluation Branch.
PUB DATE	1998-00-00
NOTE	9p.; For related documents, see SE 061 923-927. Printed on dark colored paper.
AVAILABLE FROM	Alberta Education, Student Evaluation Branch, 11160 Jasper Avenue, Edmonton, Alberta T5K 0L2, Canada.
PUB TYPE	Reports - Evaluative (142)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Academic Achievement; Academic Standards; *Chemistry; Foreign Countries; High Schools; Science Education; Student Evaluation; *Test Results
IDENTIFIERS	*Alberta Grade Twelve Diploma Examinations

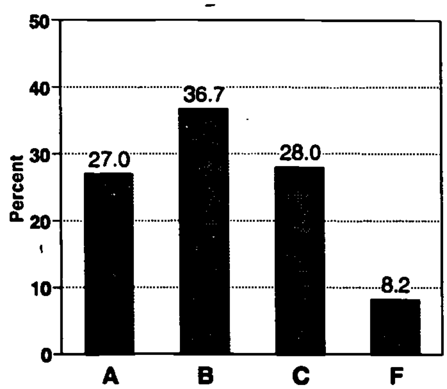
ABSTRACT

The summary information contained in this report provides teachers, school administrators, students, and the general public with an overview of the results from the June 1998 administration of the Chemistry 30 Diploma Examination by the Alberta Department of Education in Canada. This information is most helpful when used with the detailed school and jurisdiction reports that are provided to schools and school jurisdiction offices. Findings indicate that 91.7% of the 8,004 students who took the test achieved the acceptable standard, and 21.5% of those students achieved the standard of excellence. Topics discussed include a description of the examination, achievement of standards, results and examiners' comments, multiple-choice and numerical-response questions, and written-response questions. (ASK)

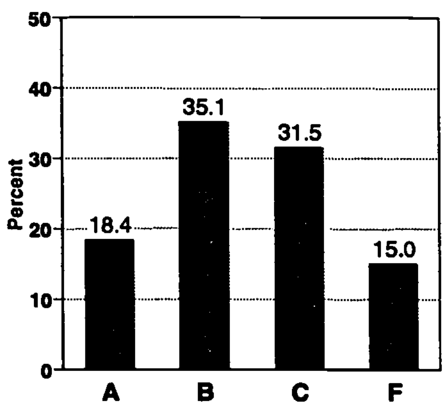
Chemistry 30

Diploma Examination Results
Examiners' Report for June 1998

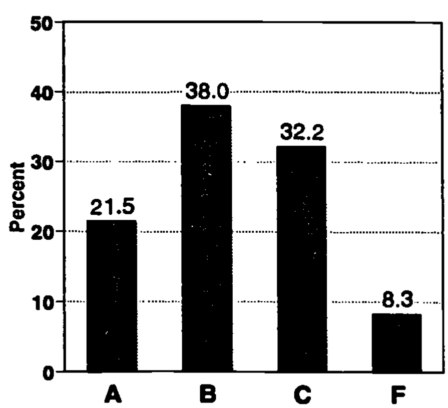
School-Awarded Mark



Diploma Examination Mark



Final Course Mark



The summary information in this report provides teachers, school administrators, and students with an overview of results from the June 1998 administration of the Chemistry 30 Diploma Examination. This information is most helpful when used in conjunction with the detailed school and jurisdiction reports that are provided electronically to schools and school jurisdiction offices. A provincial report containing a detailed analysis of the combined November, January, June, and August results is made available annually.

Description of the Examination

The Chemistry 30 Diploma Examination consists of 44 multiple-choice questions worth 55%, 12 numerical-response questions worth 15%, and 2 written-response questions worth 30% of the total examination mark.

Achievement of Standards

The information reported is based on the final course marks achieved by 8 004 students in Alberta who wrote the June 1998 examination. This represents a decrease of 137 compared with June 1997.

- 91.7% of the 8 004 students achieved the acceptable standard (a final course mark of 50% or higher).
- 21.5% of the students achieved the standard of excellence (a final course mark of 80% or higher).

Approximately 52.8% of the students who wrote the June 1998 examination were female. Of those, 91.7% of the female students achieved the acceptable standard for a final course mark, while 20.0% achieved the standard of excellence for a final course mark.

Approximately 47.2% of the students who wrote the June 1998 examination were male. Of the male students who wrote the June 1998 examination, 91.7% achieved the acceptable standard for a final course mark, while 23.1% achieved the standard of excellence for a final course mark.

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Provincial Averages

- The average school-awarded mark was 69.0%.
- The average diploma examination mark was 65.3%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 67.5%.

Approximately 7.0% of the students who wrote the examination in June 1998 and received a school-awarded mark had previously written at least one other Chemistry 30 Diploma Examination during the June 1997 to June 1998 period. This sub-population (573) achieved an examination average of 62.4%, compared with 65.3% for the population (7 431) who first wrote a Chemistry 30 examination in June 1998. The group of students who rewrote increased their overall average by 12.1%.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students capable of achieving the acceptable standard will obtain a minimum mark of 50%, and students capable of achieving the standard of excellence will obtain a minimum mark of 80%. The Chemistry 30 Examination requires students to apply their understanding of concepts to new situations in a clear, concise, organized fashion and to respect the conventions of the mode of communication selected.

In the following table, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer.

For multiple-choice and numerical-response questions, the "Difficulty" indicates the proportion (out of 1) of students answering the question correctly. For written-response questions, the "Difficulty" is the mean score (out of 1) achieved by students who wrote the examination.

Questions are also classified by general learner expectations.

Knowledge:
- GLE 1 Quantitatively Predicting Outcomes
- GLE 2 Qualitatively Analyzing Systems
- GLE 3 Relationships in Energy Transfer
- GLE 4 Relationships in Electron Transfer
- GLE 5 Relationships in Equilibrium Systems
- GLE 6 Relationships in Proton Transfer

Skills:
- SPC Scientific Process and Communication Skills

Science, Technology, Society:
- STS Science, Technology, and Society Connections

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPC	STS
MC1	C	0.854		✔	✔					✔
MC2	D	0.670		✔	✔				✔	
MC3	B	0.388	✔		✔				✔	✔
NR1	74.8	0.893	✔		✔				✔	✔
MC4	C	0.474		✔	✔					✔
MC5	B	0.494		✔			✔		✔	✔
MC6	D	0.737	✔					✔	✔	✔
NR2	4.07	0.934	✔					✔	✔	✔
MC7	B	0.818	✔					✔	✔	✔
MC8	B	0.495	✔		✔				✔	✔
MC9	C	0.838	✔			✔			✔	✔
MC10	C	0.826	✔		✔				✔	
NR3	57.0	0.829	✔		✔				✔	✔
NR4	1432	0.468		✔	✔				✔	
NR5	1458	0.626		✔	✔					

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPC	STS
MC11	C	0.832		✔	✔					
MC12	D	0.678		✔	✔				✔	
MC13	B	0.789		✔		✔			✔	✔
MC14	D	0.613		✔		✔			✔	
NR6	4746	0.827	✔			✔			✔	
MC15	B	0.895		✔		✔			✔	
MC16	D	0.765		✔		✔			✔	
NR7	2143	0.548		✔		✔			✔	
MC17	A	0.475	✔			✔				
MC18	D	0.734		✔		✔				✔
MC19	C	0.404		✔		✔			✔	✔
MC20	B	0.486		✔		✔			✔	✔
MC21	D	0.391		✔		✔			✔	✔
MC22	C	0.662	✔			✔			✔	✔
MC23	B	0.709	✔			✔			✔	✔
MC24	A	0.782		✔		✔				
NR8	1845/4518	0.558	✔			✔			✔	
MC25	D	0.897		✔				✔		✔
MC26	B	0.960		✔				✔	✔	
MC27	B	0.865	✔					✔	✔	
MC28	A	0.929		✔				✔	✔	
MC29	A	0.525	✔					✔	✔	
MC30	B	0.701		✔				✔	✔	
MC31	C	0.843		✔				✔		✔
MC32	B	0.789	✔					✔	✔	✔
MC33	D	0.599		✔				✔	✔	✔
MC34	A	0.877		✔				✔		✔
MC35	C	0.735		✔				✔	✔	✔
MC36	B	0.561	✔			✔			✔	✔
NR9	8.58/8.63	0.698	✔			✔			✔	✔
NR10	*	0.352	✔			✔			✔	✔
MC37	A	0.701		✔				✔	✔	
NR11	5.12	0.225	✔					✔	✔	
MC38	C	0.656		✔				✔	✔	
MC39	D	0.817		✔			✔			
MC40	A	0.910	✔				✔		✔	✔
MC41	C	0.575		✔			✔		✔	✔
MC42	A	0.340	✔				✔		✔	✔
MC43	C	0.726		✔				✔	✔	✔
MC44	B	0.771	✔			✔			✔	✔
NR12	2.51	0.744	✔			✔			✔	✔
WR 1	–		✔(12)		✔(8)				✔(4)	✔(12)
WR 2	–		✔(12)				✔(8)		✔(4)	✔(12)

* NR10 = NR9 × 0.775

Subtests: Machine Scored and Written Response (Average by Subtest)

When analyzing detailed results, please bear in mind that subtest results **cannot** be directly compared. Results are in average raw scores.

Machine scored:	38.3 out of 56
Multiple-choice	30.6 out of 44
Numerical-response	7.7 out of 12
Written Response:	13.6 out of 24
Question 1	7.7 out of 12
Question 2	5.9 out of 12

Raw Score Average for Machine-Scored Items and Written-Response Questions by General Learner Expectation

GLE 1	Quantitatively Predicting Outcomes	30.6	out of	49
GLE 2	Qualitatively Analyzing Systems	21.5	out of	31
GLE 3	Relationships in Energy Transfer	13.0	out of	20
GLE 4	Relationships in Electron Transfer	13.6	out of	21
GLE 5	Relationships in Equilibrium Systems	7.0	out of	13
GLE 6	Relationships in Proton Transfer	13.5	out of	18
SPC	Scientific Process and Communication Skills	35.1	out of	53
STS	Science, Technology, and Society Connections	36.2	out of	57

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Multiple-Choice and Numerical-Response Questions

The following table gives results for four questions selected from the examination and shows the percentage of students in four groups that answered the question correctly. The comments following the table discuss some of the understandings and skills the students may have used to answer these questions.

Percentage of Students Correctly Answering Selected Machine-Scored Questions

Student Group	Question Number			
	MC 32	MC 42	NR 10	NR 11
All Students	78.9	34.0	35.2	22.5
Students achieving the *standard of excellence* (80% or higher, or A) on the whole examination	93.2	74.5	68.1	64.6
Students achieving the *acceptable standard* (between 50% and 79%, B or C) on the whole examination	79.2	28.6	32.7	15.8
Students who have not achieved the *acceptable standard* (49% or less, or F) on the whole examination	60.4	7.8	5.8	0.8

The following questions were selected for discussion because they exemplify the minimum requirements of the acceptable standard and of the standard of excellence.

Students achieving the acceptable standard but not the standard of excellence had no difficulty answering questions such as multiple-choice questions 6, 13, 16, 18, 23, 24, 32, and 44 and numerical-response questions 3, 6, and 12.

32. Indicators are added to three samples of acid rain from the same source. The samples with methyl orange and chlorophenol red are yellow. The sample with methyl red is red. The approximate pH of the acid rain samples is

A. 3.0
***B.** 4.6
C. 5.0
D. 5.5

For example, in **multiple-choice question 32,** most students (78.9%) were able to determine the pH of a solution based on the colours of three different indicators.

A number of students (17.8%) did not understand that the colour of an indicator in its mid pH range was a blend of its acid and base colours and, therefore, selected C or D as the correct response.

The results from this question suggest that students who do not achieve the acceptable standard have difficulty analyzing an indicator table.

Students achieving the standard of excellence had no difficulty answering questions such as multiple-choice questions 3, 4, 5, 8, 17, 20, and 42 and numerical-response questions 4 and 10.

42. If the equilibrium constant, K_{eq}, for the dissolving of tooth enamel has a value of 2.0×10^{-30}, then the K_{eq} value for the reverse reaction is

***A.** 4.83×10^{29}
B. 4.83×10^{15}
C. 2.07×10^{-16}
D. -2.07×10^{-30}

For example, in **multiple-choice question 42,** 74.5% of students achieving the standard of excellence recognized that the K_{eq} of a reverse reaction is the inverse of that of the forward reaction. This indicates an understanding of the

Use the following additional information to answer the next two questions.

Titration of Sulphurous Acid with Potassium Permanganate

Volume of sulphurous acid samples = 100.0 mL
Concentration of $KMnO_{4(aq)}$ = 0.0310 mol/L

	Volume of $KMnO_{4(aq)}$			
Trial	**1**	**2**	**3**	**4**
Final buret reading (mL)	9.50	18.15	26.75	34.75
Initial buret reading (mL)	1.00	9.50	18.15	26.75
Final colour of mixture	pink	pink	pink	colourless

Use the value selected for **Numerical Response 9** to answer **Numerical Response 10.***

Numerical Response

10. The concentration of sulphurous acid in the sample is __________ mmol/L.
(Record your answer to three digits on the answer sheet.)

Answer: NR9 × 0.775 or 6.65

Numerical Response

11. When 0.10 mol of $NH_4NO_{3(s)}$ is dissolved in water to produce 1.0 L of solution, the pH of the solution is __________.
(Record your answer to three digits on the answer sheet.)

Answer: 5.12

equilibrium expression as the product concentrations divided by the reactant concentrations.

Many students (42.1%) treated the K_{eq} as if it were a ΔH in that they simply reversed the sign in order to determine the K_{eq} of the reverse reaction.

In **numerical-response question 10,** 68.1%of students achieving the standard of excellence were able to correctly perform a stochiometric calculation from experimental titration data. They accurately completed a set of three linked questions involving the balancing of a redox equation (MC 36), the calculation of an average volume (NR 9), and the calculation of a concentration (NR10).

It should be noted that over 25% of students used a 1:1 coefficient ratio in performing this calculation even though none of the choices for the balancing of the equation (MC36) showed a 1:1 ratio.

Numerical-response question 11 created difficulty for most students. Only 22.5% of all students were able to calculate the pH of the system.

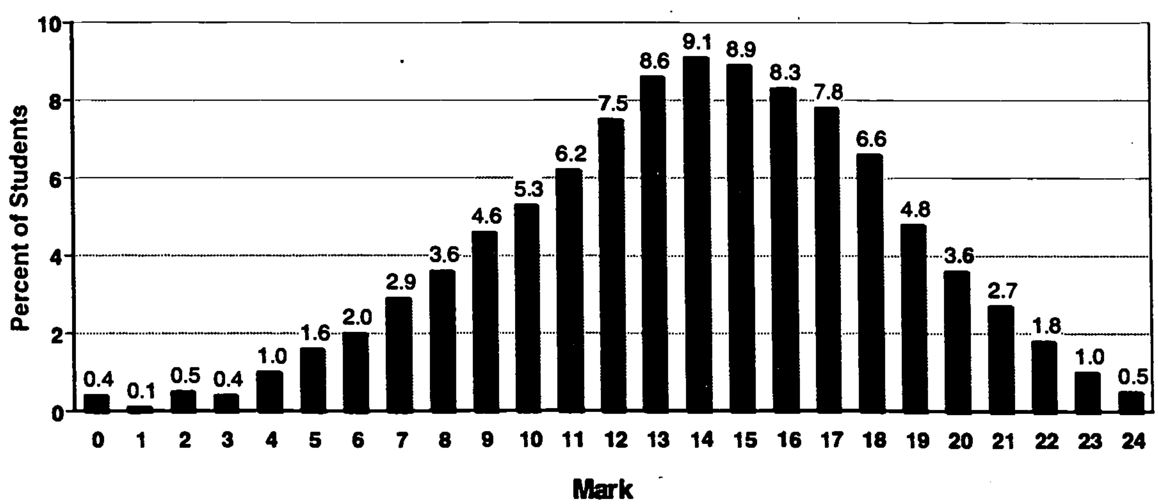
Of all students, 30.2% incorrectly assumed that $NH_4NO_{3(aq)}$ was a strong acid. Hence, they calculated the pH of the 0.10 mol/L solution to be 1.00.

A further 6.8% of students assumed that $NH_4NO_{3(aq)}$ was a strong base and calculated the pH to be 13.0.

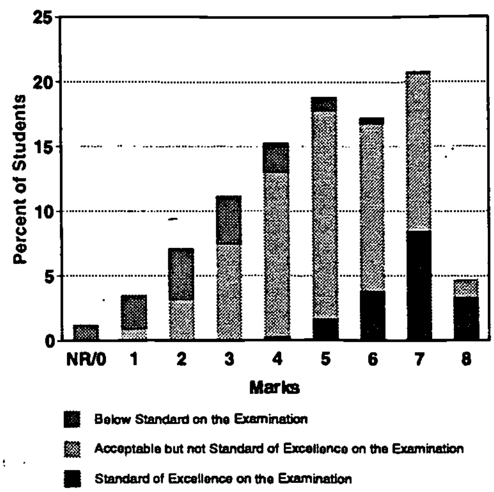
Written-Response Questions

Of all the students who wrote the examination, 71.2% received a mark of 12 or higher out of 24 on the written-response questions. The average mark on the written-response questions was 13.7.

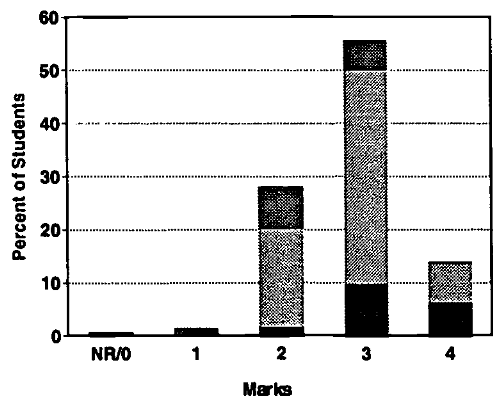
Distribution of Marks for Written Response



Distribution of Marks for Question 1 - Scale 1



Distribution of Marks for Question 1 - Scale 2



Written-response question 1 was answered better than expected. The question was selected to measure students' ability to quantitatively analyze calorimetric data to determine the molar enthalpy of solution for a household product. Students were asked to identity an advantage and a disadvantage of using the driveway product by applying their knowledge of chemistry. Overall, students attempted all parts of the question. However, many students attempted to write a reaction as opposed to indicating a dissociation of the salt in water to form an aqueous solution. Many students demonstrated a basic misconception of the acidity of a neutral salt solution.

Students who did not achieve the acceptable standard averaged 2.57 on the chemistry content scale and 2.21 on the communication scale. Of the students who did not achieve the acceptable standard for this question, 4.3% did not attempt it. Overall, they averaged 4.78 by demonstrating an understanding of a valid method to determine the moles of $CaCl_{2(s)}$. These students attempted to calculate the energy associated with the temperature change for the water, or they attempted to calculate the energy for the phase change of the salt; however, they neglected to combine the two energy changes correctly. The values used for the specific heat capacity of water were used indiscriminately. The most common errors were the use of an incorrect formula for calcium chloride (i.e. $CaCl_{(s)}$), the use of 2.01J/g°C, and the heat of formation of calcium chloride for the specific heat capacity of liquid water. These problems illustrate a limited understanding of calorimetric analysis of experimental data. The addition of J and kJ was also problematic for many students. States of matter were either not applied or were used inconsistently throughout the response. Many students restate the question in part c rather than generating an answer that demonstrated an understanding of chemistry concepts. Many students identified an acceptable advantage or a disadvantage of using the household product, but not both. Students who did not achieve the acceptable standard consistently exhibited poor organizational and communication skills.

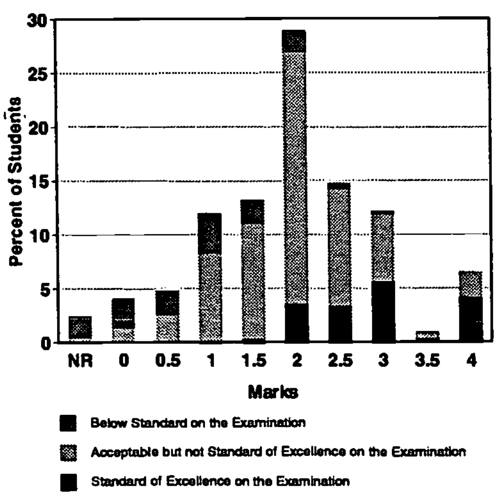
Students who achieved the acceptable standard but not the standard of excellence on the examination were expected to score from 6 to 9 for their combined mark. They averaged 4.54 on the chemistry content scale and 2.58 on the communication scale. Overall, they averaged 7.12 by recognizing that there were two components, potential and kinetic energy (m/M $\Delta H = mc\Delta t$) required to answer the question. However, a number of students calculated a positive potential energy value and a negative kinetic energy value resulting in an incorrect molar enthalpy answer. Some students had difficulty determining the mass of water in part b. Many students assumed that $CaCl_{2\,(s)}$ dissolved to form $HCl_{(aq)}$ or $Cl_{2(g)}$ (i.e. $CaCl_{2(s)} \rightarrow Ca_{(s)} + Cl_{2(g)}$ or $CaCl_{2(s)} + H_2O_{(l)} \rightarrow CaO_{(s)} + HCl_{(aq)}$) thus illustrating a misconception that water reacts with salt. As a result, students described massive amounts of energy generated and concern that the driveway could melt. It should be noted, however, that a dissociation equation was not required for full marks to be awarded. Generally, these students' responses were well organized, with units and significant digits applied correctly.

Students who achieved the standard of excellence were expected to score 10 or better. They averaged 6.69 on the chemistry content scale and 3.25 on the communication scale. Of these students, 19.1 % attained a perfect score on the first scale, and 35.4 % attained a perfect score on the second scale. These students accurately analyzed experimental calorimetric data obtained from an unfamiliar household product. Usually, these students provided more than one advantage and disadvantage, as well, they supported each selection. These students demonstrated excellent attention to detail. The responses were well organized, clear, and concise.

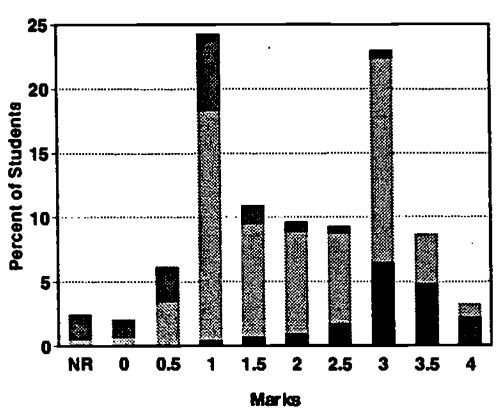
The results for this question indicate the importance of teaching experiment-based calorimetric analysis. Many students had difficulty understanding exothermic solubility and did not include a negative sign with the molar enthalpy value to indicate an exothermic change, thus illustrating a lack of chemistry communication understanding and skill.

On this 12-mark question, the average mark was 7.74, or 64.5 % of the available mark.

Distribution of Marks for Question 2 - Scale 1



Distribution of Marks for Question 2 - Scale 2



Written-response question 2 was also answered better than expected. The question was selected to measure students' understanding of equilibrium systems. Students were required to calculate the K_{eq} for a homogenous system and to use the magnitude of the K_{eq} value to determine whether the products or reactants were favoured at equilibrium.

Overall, students were familiar with equilibrium systems and how to write an equilibrium expression for specific chemical reaction. It was evident, based on student responses, that some students were unclear as to what the term 'favoured' meant. Some students confused percent reaction with K_{eq}. They calculated a percent reaction and attempted to explain the equilibrium position in terms of Le Chateliers' Principle. Students were unfamiliar with homogeneous equilibrium problems for liquid systems and they also demonstrated a limited understanding of solvent systems. Students were expected to include water in a homogenous system equilibrium expression. The most common error, however, was the determination of the equilibrium concentrations of $C_2H_5OH_{(l)}$ and $C_2H_5COOH_{(l)}$. If students read carefully and understood the reaction information provided, they should have been able to determine that the products were favoured before performing the K_{eq} calculation.

Students who did not achieve the acceptable standard averaged 0.89 out of 4 on the chemistry content scale; therefore, they received a content mark of 1.78 out of 8. These students averaged 0.91 on the communication scale. Of the students who failed this question, 12.5% did not attempt it. The overall average then was 2.69 out of 12 on the question. They recognized that the question was related to chemical equilibrium and were able to write an equilibrium expression. They correctly substituted products over reactants in the expression; however, only initial reagent concentrations were used. Few students attempted to calculate the equilibrium concentrations of the reactants. Students were unable to explain how the K_{eq} value related to the favouring of reactants or products at equilibrium. A number of students identified a K_{eq} value of 0.642 being below 0. A common misconception for this 1:1:1:1 reaction was to use $K>0$ instead of $K>1$ as the criterion. Some students suggested that neither side of the reaction was favoured at equilibrium because the total number of moles of product and reactant were the same. Many students treated the esterification reaction as an acid-base reaction. They struggled with a conclusion based on $K_{(eq)}$. They also tended to focus on the strength of acid and conjugate base strengths. Students did not recognize that the system had a total volume of 1L and had difficulty understanding the inequality symbols used. These students' responses were poorly organized and contained many errors in conventions.

Students who achieved the acceptable standard but not the standard of excellence were expected to score from 6 to 9 for their combined mark. They averaged 1.92 out of 4 on the chemistry content scale that resulted in a content mark of 3.84 out of 8. These students averaged 1.95 on the communication scale. Overall, they averaged 5.79 out of 12 on the question because they could write a K_{eq} expression and could interpret the K_{eq} value properly to an accurate conclusions. A number of students did not include water in the K_{eq} calculation; as well, they suggested that water is automatically discarded in all equilibrium expressions. Some students included water in the K_{eq} expression but not in the calculations, or thus used inappropriate values such as 18.02, 4.19, or 285.8 for water. The most common error was the determination of the equilibrium concentrations of the reactants before substituting concentrations into the equilibrium expression. A few students used volumes of 0.25L and 0.50L rather than the 1L designated to calculate the equilibrium concentrations. These students' responses were generally well organized with minor errors in conventions.

Students who achieved the standard of excellence were expected to score 10 or better. They averaged 2.91 out of 4 on the chemistry content scale that resulted in a content mark of 5.82 out of 8. These students averaged 3.02 on the communication scale. Of these students, 23.5 % attained a perfect score on the first scale and 12.9 % attained a perfect score on the second scale. Overall, they averaged 8.84 out of 12 on the question. Students achieving the standard of excellence did so because they could successfully calculate the moles for each reagent by setting up an ICE (initial, change, and equilibrium) table and then determining the equilibrium concentrations. They were able to distinguish between initial and equilibrium data. Many of these students consciously included water in their calculations. These students used logic to override incorrectly calculated K_{eq} values when they were incongruent with the data provided in the question.

These students presented their answers in a succinct, well-written, and organized manner with minor errors in abbreviations or minor omission of states of matter. Units were used correctly when needed and omitted for K_{eq} values where they were unnecessary.

It should be noted that, for this open-ended question, students who made the incorrect assumption that all liquids are pure and therefore do not change in concentration when mixed could receive full marks; that is, provided that they wrote an equilibrium expression and articulated what the $K_{eq}=1$ value meant. Students who correctly used ICE to calculate the K_{eq} but did not include water in the calculations could receive a maximum score of 10 out of 12 for this question. The percentage mark loss when a student omitted water in the calculation is comparable to a single machine-scored question for a specific chemistry concept.

On this 12-mark question, the average mark was 5.87 or 48.9 % of the available mark.

For further information, contact Marlene McDonald (mmcdonald@edc.gov.ab.ca), Caroline Heppell (cheppell@edc.gov.ab.ca), or Corinne McCabe (cmccabe@edc.gov.ab.ca) at the Student Evaluation Branch at 427-0010. To call toll-free from outside of Edmonton, dial 310-0000.

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