Grading Standards
Chemistry 3202
June 2008

Pre-Marking Appraisal

The examination was considered fair and had coverage of each unit of study and each level of cognitive learning as per the Table of Specs.

Post Marking Report

a) Marking Standard and Consistency

Marker reliability was checked by obtaining a random sample of 50 examinations. These examinations were scored on separate back flaps with no physical markings on the original examinations and were held by the Chief Marker for recirculation throughout the marking period. These papers were corrected by the marking board again, and the initial and subsequent marks were compared. Any discrepancies in marking were reviewed and discussed with individual markers. Each marker also made on-going notes regarding partial marks and scoring for their particular question. Whenever a non-common error occurred, it was scored by consensus of the board and made note of, for scoring consistency.

b) Summary

Overall performance in the Chemistry 3202 examination improved from June 2007 to June 2008. As in past years, however, performance was lower for items that assessed outcomes from core Labs and STSE units. Core Labs and STSE units enrich and enhance material in each unit of the course. It is essential that teachers complete all core labs and STSE units to ensure that students are prepared for the examination. On provincial examinations, Core Lab and STSE outcomes are often assessed at higher cognitive levels. Teachers, therefore, should assess these areas of the course throughout the school year in a similar manner.

Teachers should also encourage students to read questions carefully and critically. Very often on the provincial examination, errors occur because students fail to read the whole question. If they read the complete question or read it several times, they are less likely to misinterpret the item and are more likely to perform better.

c) Commentary on Responses

Part I - Selected Response - Total Value: 50%

Item #20: Students did not understand that the $[OH^-]$ is double the given concentration of $Ba(OH)_2$.

Item #24: Students showed a poor understanding of which substance was the titrant.

Item #25: Students did not know the definition of an indicator.

Item #28: Students had trouble picking the best indicator for the titration since the titration curve was not given.

Item #39: Students chose the largest number instead of the most negative number, which indicates a more exothermic reaction.

Item #40: Students did not realize that they had to divide by 2 to get the answer in kJ/mol.

Item #42: Students chose the substance that was oxidized instead of the oxidizing agent.

Item #50: Students chose the calculated voltage as the minimum instead of selecting a required larger voltage.

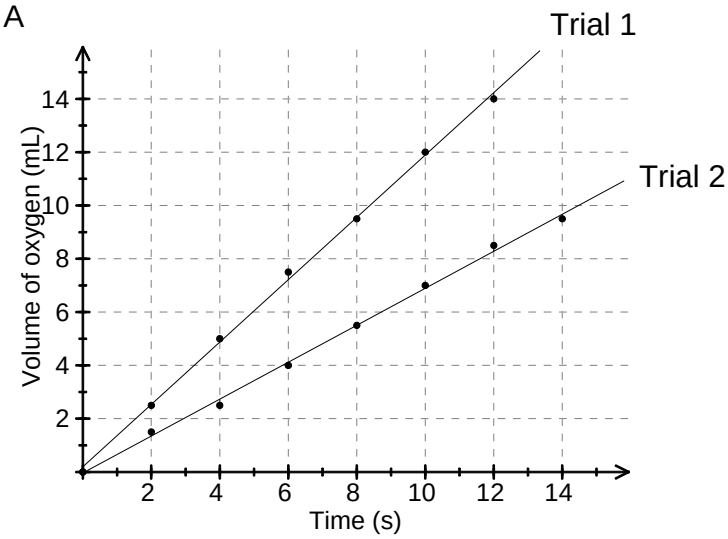
Part II - Constructed Response - Total Value: 50%

Value

4% 51.(a) In a lab, data from two trials of the reaction below were collected. Graph A illustrates the volume of oxygen produced over time for each trial.

$$2\ H_2O_2(aq) \rightarrow 2\ H_2O(\ell) + O_2(g)$$

Graph A



i) Which trial has the highest rate of O_2 production?

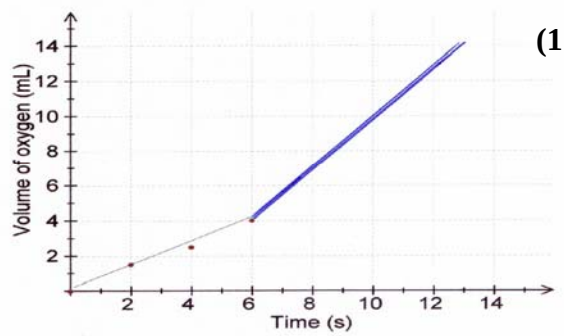
Trial 1 (1 mark)

Common Error

Students chose trial 2 because data was recorded for a longer time.

ii) On Graph B below, show how trial 2 will change if a catalyst is added after 6 seconds.

Graph B



(1 mark)

Common Error
Students started at time = 0 with their line.

iii) Explain how one factor, other than a catalyst, could cause the different rates for trials 1 and 2 shown in Graph A.

Different concentration of H_2O_2 used for trials 1 & 2 (1 mark)

higher concentration has more reacting particles resulting in more "successful" collisions (1 mark)

OR Different temperature used for trials 1 & 2

higher temp causes reacting particles to move faster resulting in more collisions with more intensity resulting in more "successful" collisions

Common Errors
Students:

- who chose concentration did not explain that this meant there were more reacting particles.
- treated the reaction as an equilibrium and used LCP.
- cited human error as a reason, but this was not accepted.

Value

4% 51.(b) The mechanism below shows the decomposition of ozone in the upper atmosphere.

Step	Reaction Mechanism
1	$O_3(g) \rightarrow O_2(g) + O(g)$
2	$O_3(g) + NO(g) \rightarrow NO_2(g) + O_2(g)$
3	$NO_2(g) + O(g) \rightarrow NO(g) + O_2(g)$

i) What is the equation for the overall reaction?

$2\ O_3\ (g) \rightarrow 3\ O_2\ (g)$ **1 mark**

Common Error
Students did not omit the catalyst or reaction intermediates from the overall equation.

ii) Identify reaction intermediate(s) and/or catalyst(s) present.

Reaction Intermediate(s): **O and NO_2** **1 mark**

Catalyst(s): **NO** **1 mark**

Common Error
Students gave the catalyst as the reaction intermediate and vice versa.

iii) Step 1 of the reaction mechanism does not occur unless ultraviolet radiation is present. Describe the role that ultraviolet radiation plays in the reaction.

It provides the energy needed to get bonds to break (activation energy).

1 mark

Common Error
Students did not equate ultraviolet radiation with a source of energy.

Value

3% 51.(c) 0.500 mol of $H_2O_2(g)$ are placed in a 2.00 L flask at a certain temperature and allowed to establish the equilibrium below. If there are 0.150 mol of $O_2(g)$ in the flask at equilibrium, calculate K for the reaction.

	$2\ H_2O_2(g)$	$\rightleftharpoons$	**$2\ H_2O(g)$**	**+ $O_2(g)$**	
I	**c = $\frac{0.500\ mol}{2.00\ L}$ 0.250 mol/L**		**0**	**0**	
C	- 2*x*		+ 2*x*	+ *x*	
E	0.250 - 2*x*		2*x*	*x*	(½ mark)

$[O_2]_{eq} = \frac{0.150\ mol}{2.00\ L} = 0.0750\ mol/L = x$ (½ mark)

$[H_2O]_{eq} = 2x = 2\ (0.0750) = 0.150\ mol/L$ (½ mark)

$[H_2O_2]_{eq} = 0.250 - 2x = 0.250 - 2\ (0.0750) = 0.100\ mol/L$ (½ mark)

$$K = \frac{[H_2O]^2[O_2]}{[H_2O_2]^2} = \frac{(0.150)^2(0.0750)}{(0.100)^2} = 0.169$$

(½ mark) (½ mark)

Common Errors

Students:

- did not include the information for H_2O (g) in their calculation.
- did not square the denominator.
- did not change mole values to concentration values.

Value

2% 51.(d) At 25℃ the value of K is 1.6×10^{-21}, while at 827℃ the value of K is 10.0. Explain whether the reaction is endothermic or exothermic.

$$C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g)$$

Since K increases with an increase in temperature we know the equilibrium shifts right according to LCP. It does this to try to decrease the temperature by using up energy. 1 mark

Therefore energy must be in the reactants and the reaction is endothermic. 1 mark

Common Errors

Students:

- confused the terms endothermic and exothermic.
- limited their explanation to information given and did not clarify that the direction of shift indicated where the energy term is.

2% 52.(a) Determine the Br∅nsted-Lowry acid-base neutralization reaction that occurs between $NaHCO_3(aq)$ and $NH_4NO_2(aq)$.

Species:	Na^+	HCO_3^-	NH_4^+	NO_2^-	H_2O	
	neutral	A/B	A	B	A/B	
		SB	SA			

NH_4^+ + HCO_3^-		$\rightleftharpoons$	NH_3 + H_2CO_3
(½ mark)	**(½ mark)**	**(½ mark)**	**(½ mark)**

Common Errors

Students:

- did not dissociate the compounds, especially NH_4NO_2.
- did not identify NH_4^+ as a stronger acid than HCO_3^-.
- did not use an equilibrium arrow.

Value

4% 52.(b) Calculate the pH of a 0.297 mol/L solution of hypochlorous acid, HOCl(aq), which has $K_a = 2.9 \times 10^{-8}$.

	HOCl	**+ H_2O $\rightleftharpoons$**	**H_3O^+**	**OCl^-**	
I	**0.297**		**0**	**0**	
C	**- *x***		**+ *x***	**+ *x***	
E	**0.297 - *x***		**+ *x***	**+ *x***	**(1 mark)**

check $\frac{[HOCl]}{K_a} = \frac{0.297}{2.9 \times 10^{-8}} = 10200000 > 500$ **(½ mark)**

thus assume 0.297 - *x* ~ 0.297 **(½ mark)**

$K = \frac{[H_3O^+][OCl^-]}{[HOCl]}$ **(½ mark)**

$2.9 \times 10^{-8} = \frac{x^2}{0.297}$ **(½ mark)**

$x = 9.2(8) \times 10^{-5} = [H_3O^+]$ **(½ mark)**

$pH = -\log [H_3O^+] = -\log [9.2(8) \times 10^{-5}] = 4.03$ **(½ mark)**

Common Errors

Students:

- did not show relationship between species; ie: ICE table.
- did not set up the K expression.
- forgot to solve for pH once they had *x*, the concentration of H_3O^+.

Value

2% 52.(c) Using the data below, determine which solution is the best conductor of electricity, and explain why.

	Solution A	Solution B	Solution C
Name	HCl(aq)	CH_3COOH(aq)	LiOH(aq)
Volume (mL)	45	35	35
Moles of Solute	1.10×10^{-3}	1.50×10^{-2}	1.50×10^{-2}

Solution C **(1 mark)**

Solution C goes completely to ions like solution A, but is more concentrated so there will be more ions in solutions making it a better conductor. (½ mark)

Solution C has the same concentration as B, but it is strong and will produce more ions in solution than the weak acid (B) which does not ionize completely. (½ mark)

Solution A is a strong acid which ionizes completely.

$$[HCl] = \frac{1.10 \times 10^{-3}\ \text{mol}}{0.045\ \text{L}} = 0.024\ \text{mol/L}$$

Solution B is a weak acid which does not ionize completely.

$$[CH_3COOH] = \frac{1.50 \times 10^{-2}\ \text{mol}}{0.035\ \text{L}} = 0.43\ \text{mol/L}$$

Solution C is a strong base which dissociates completely.

$$[LiOH] = \frac{1.50 \times 10^{-2}\ \text{mol}}{0.035\ \text{L}} = 0.43\ \text{mol/L}$$

Common Errors

Students:

- did not recognize that a strong base also conducts an electric current.
- stated that a lower concentration solution was a better conductor than a higher concentration solution.

Value

4% 52.(d) Calculate the concentration and pH of a solution formed by mixing 25.00 mL of 0.125 mol/L HBr(aq), with 70.00 mL of 0.242 mol/L LiOH(aq).

$HBr(aq) + LiOH(aq) \rightarrow H_2O(l) + LiBr(aq)$ **(½ mark)**

or $H_3O^+(aq) + OH^-(aq) \rightarrow 2\ H_2O(l)$

$n_{(HBr)} = c\ v = (0.125\ mol/L)\ (0.02500\ L) = 0.00312(5)\ mol$ **(½ mark)**

$n_{(LiOH)} = c\ v = (0.242\ mol/L)\ (0.07000\ L) = 0.0169(4)\ mol$

Since ratio: HBr : LiOH is 1 : 1 then
0.00312(5) mol of HBr reacts with 0.00312(5) mol of LiOH.
Thus LiOH (OH^-) is in excess.
Excess OH^- : 0.0169(4) – 0.00312(5) = 0.0138(15) mol **(½ mark)**

$c_{(LiOH)} = \frac{0.0138(15)\ mol}{0.09500\ L} = 0.145(4)\ mol/L = [OH^-]$ **(1 mark)**

$pOH = -\log [OH^-] = 0.837$ **(½ mark)**

$pH = 14.000 - pOH = 14.000 - 0.837 = 13.163$ **(½ mark)**

Science Communication:	**½ mark units** **½ mark significant figures**

Common Errors

Students:

- did not write a balanced chemical equation showing the ratio is 1:1.
- incorrectly calculated the number of moles.
- confused pH and pOH.
- ignored units and significant figures.

Value

2% 52.(e) A person's breathing rate is slowed as a result of a stroke. With reference to the equations below, explain if the person is at risk for acidosis or alkalosis.

$$CO_2(g) + H_2O(\ell) \rightleftharpoons H_2CO_3(aq)$$

$$H_2CO_3(aq) + H_2O(\ell) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$$

A slowed breathing rate increases the amount of CO_2; eqbm will shift right to try to decrease it, thus producing more H_3O^+ and pH drops. (1 mark)

Person is at risk of acidosis with a drop in pH level of the blood.

(1 mark)

Common Errors

Students:

- did not recognize the concepts of acidosis and alkalosis.
- did not support their choice.
- chose both positions and argued for both.

5% 53.(a) 1125.4 g of water at 10.36℃ is cooled to 0℃ and frozen.

i) Calculate how much heat is released in this process.

$q_1 = m\,c\,\Delta T = (1125.4\text{ g})\,(4.184\text{ J/g}\bullet°\text{C})\,(-10.(36)°\text{C})$
$= -48(782)\text{ J} = -48.(8)\text{ kJ}$ **(1 mark)**

$q_2 = n\,\Delta H_{solid} = \dfrac{1125.4\text{ g}}{18.02\text{ g/mol}} \times -6.02\text{ kJ/mol}$
$= (62.45(3)\text{ mol})\,(-6.02\text{ kJ/mol})$
$= -376\text{ kJ}$ **(1 mark)**

$\Delta E = q_1 + q_2 = -48.(8)\text{ kJ} + -376\text{ kJ} = -425\text{ kJ}$ **(1 mark)**

Science Communication	**½ mark units** **½ mark significant figures**

Common Errors
Students:
- calculated only one q value; usually the one from $mc\Delta T$.
- used incorrect significant figures particularly when adding and subtracting.
- used incorrect constant in calculation; ie: 6.02 instead of 4.184.
- solved for q, then tried to solve for ΔH.

ii) Calculate the number of moles of ammonia that can undergo a phase change from liquid to gas, using the energy from the process above.

$NH_3(\ell) \rightarrow NH_3(g) \qquad \Delta H°_{vap} = +23.3\text{ kJ/mol}$

$n = \dfrac{q}{\Delta H} = \dfrac{425\text{ kJ}}{23.3\text{ kJ/mol}} = 18.2\text{ mol}$ **(1 mark)**

Common Errors
Students:
- used one of the q values from part one instead of the total energy.
- used $n = \Delta H / q$ not the correct formula $n = q / \Delta H$.

4% 53.(b) Using the data determine ΔH for the reaction below

$$C(s) + 2\,H_2(g) \rightarrow CH_4(g)$$

× 1	$C(s) + O_2(g)$	$\rightarrow$	$CO_2(g)$	$\Delta H = \sim 393.5$ kJ
× 2	$H_2(g) + \frac{1}{2} O_2(g)$	$\rightarrow$	$H_2O(\ell)$	$\Delta H = \sim 285.8$ kJ
× -1	$CH_4(g) + 2\,O_2(g)$	$\rightarrow$	$CO_2(g) + 2\,H_2O(\ell)$	$\Delta H = \sim 890.5$ kJ

$C(s) + O_2(g)$	$\rightarrow$	**$CO_2(g)$**	**$\Delta H = \sim 393.5$ kJ**	**(1 mark)**
$2\,H_2(g) + O_2(g)$	$\rightarrow$	**$2\,H_2O(\ell)$**	**$\Delta H = \sim 571.6$ kJ**	**(1 mark)**
$CO_2(g) + 2\,H_2O(\ell)$	$\rightarrow$	**$CH_4(g) + 2\,O_2(g)$**	**$\Delta H = +890.5$ kJ**	**(1 mark)**
$C(s) + 2\,H_2(g)$	$\rightarrow$	**$CH_4(g)$**	**$\Delta H = \sim 74.6$ kJ**	**(1 mark)**

Common Errors

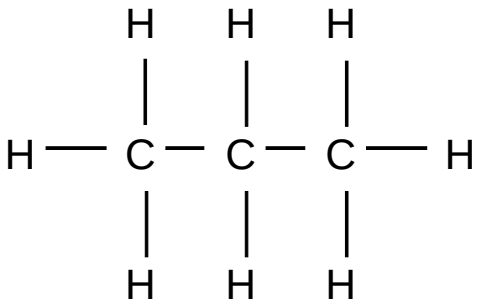
Students:

- did not show complete workings; typically only manipulated the ΔH values and not the equations as well.
- made computational errors.
- tried to use the formula $\Delta H_{rxn} = \sum n \Delta H_f°(\text{products}) - \sum n \Delta H_f°(\text{reactants})$.

Value

4% 53.(c) Use the data below to calculate the fuel value of propane.

$$C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(g)$$



Bond	Bond Energy (kJ/mol)
C ~H	338
C ~C	347
O = O	498
C = O	745
H ~O	460

$$2 \times (C - C) + 8 \times (C - H) + 5 \times (O = O) \rightarrow 6\ (C = 0) + 8 \times (O - H)$$

$$\Delta H = \sum BE_{reactants} - \sum BE_{products}$$

$$= [\ (2 \times 347) + (\ 8 \times 338) + (5 \times 498)] - [\ (\ 6 \times 745) + (8 \times 460)]$$

$$= [\ 694 + 2704 + 2490\ ] - [\ 4470 + 3680\ ]$$ **(2 ½ marks)**

$$= 5888 - 8150$$

$$= -\ 2262\ kJ$$ **(½ mark)**

2262 kJ released for 1 mole of propane or 44.11 g.

$$FV = \frac{q}{m} = \frac{2262\ kJ}{44.11\ g} = 51.38\ kJ/g$$ **(1 mark)**

Common Errors

Students:

- calculated ΔH for propane only.
- forgot to include the C - C bond in the calculation for propane.
- calculated ΔH for the equation, but then only used the value for propane to calculate fuel value.

Value

3% 54.(a) Balance the redox reaction below under acidic conditions.

$$H_2S + Cr_2O_7^{2-} \rightarrow Cr^{3+} + S$$

half rxn1: $\mathbf{H_2S \rightarrow S + 2\,H^+ + 2\,e^-}$ **] × 3** **(½ mark)**

half rxn 2: $\mathbf{6\,e^- + 14\,H^+ + Cr_2O_7^{2-} \rightarrow 2\,Cr^{3+} + 7\,H_2O}$ **] × 1** **(1 mark)**

$\mathbf{3\,H_2S \rightarrow 3\,S + 6\,H^+ + 6\,e^-}$ **(½ mark)**

$\mathbf{6\,e^- + 14\,H^+ + Cr_2O_7^{2-} \rightarrow 2\,Cr^{3+} + 7\,H_2O}$

$\mathbf{3\,H_2S + 8\,H^+ + Cr_2O_7^{2-} \rightarrow 3\,S + 2\,Cr^{3+} + 7\,H_2O}$ **(1 mark)**

Common Errors

Students:

- did not balance electrons properly.
- did not include " S " in their overall balanced equation.
- reversed one or both half reactions.

Value

4% 54.(b) Calculate how many minutes it would take to produce 5.40 g of aluminum from molten bauxite, Al_2O_3, using a current of 5.00 A.

$Al^{3+} + 3\ e^- \rightarrow Al$ **(½ mark)**

$n_{Al} = \frac{m}{M} = \frac{5.40\ g}{26.98\ g/mol} = 0.200(1)\ mol$ **(½ mark)**

$n_e = 0.200(1)\ mol\ Al \times \frac{3\ mol\ e^-}{1\ mol\ Al} = 0.600(3)\ mol$ **(½ mark)**

$Q = n_e \times F = (0.600(3)\ mol)\ (96500\ C/mol\ e^-) = 579(29)\ C$ **(½ mark)**

$t = \frac{Q}{I} = \frac{579(29)}{5.00} = 115(86)\ s = 193\ min$ **(1 mark)**

Science Communication	**½ mark units** **½ mark significant figures**

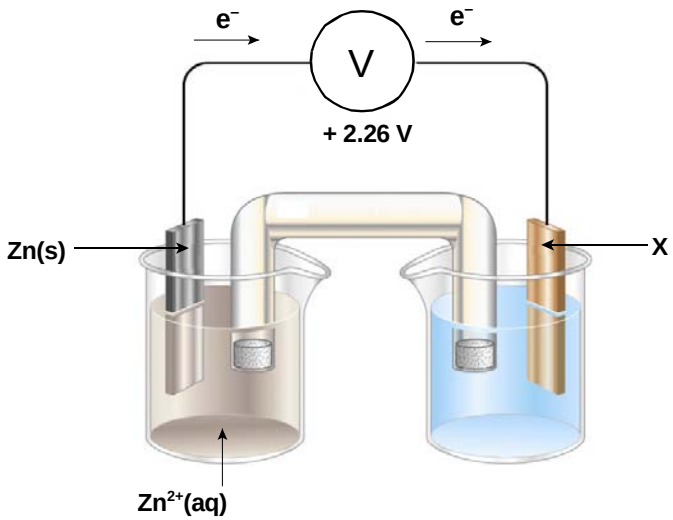
Common Errors

Students:

- did not include the reduction half reaction; they often tried to dissociate Al_2O_3 and balance with H_2O and O_2.
- often used the molar mass of Al_2O_3 and not Al in calculation.
- did not use mole ratio to calculate the moles of electrons but instead used moles of Al.
- confused Q with q from the thermo unit.
- did not convert final answer to minutes.

Value

3% 54.(c) Using the electrochemical reactions for the cell below, identify electrode X.



Electrons leaving Zn electrode; oxidation

$Zn \rightarrow Zn^{2+} + 2e^-$ $\mathscr{E} = +0.76$ V **(1 mark)**

$\mathscr{E}$anode + $\mathscr{E}$cathode = $\mathscr{E}$cell

+0.76 V + $\mathscr{E}$cathode = + 2.26

$\mathscr{E}$cathode = 2.26 - 0.76 V = 1.50 V **(1 mark)**

from table: $Au^{3+} + 3e^- \rightarrow Au$ $\mathscr{E} = +1.50$ V

thus the electrode X is Au. **(1 mark)**

Common Errors

Students:

- calculated values based on an electrolytic cell.
- did not change sign for E° value when used as oxidation.
- mixed up signs on E° values when using the formula to calculate.
- said that Au^{3+} was the cathode and not Au, or did not state the answer and just gave the half reaction.
- stated only that X was the cathode and not identifying the "unknown metal".

TABLE 1
CHEMISTRY 3202 ITEM ANALYSIS
SELECTED RESPONSE (PART I)

Item	Answer	Responses			
		A	B	C	D
		%	%	%	%
1	B	9.3	86.6	1.4	2.7
2	C	4.8	24.3	63.3	7.5
3	C	6	0.9	92.4	0.7
4	B	5	81.4	8.8	4.7
5	C	11.3	20.8	58.1	9.7
6	D	2	1.9	4	92
7	C	6.4	17.6	70.7	5.3
8	C	8.1	8.3	41.4	42.2
9	D	5.5	5.6	9.2	79.6
10	B	1.1	96.1	0.6	2.1
11	B	3.9	87.2	3.4	5.4
12	D	4	3.6	13.9	78.4
13	D	4	1.5	5	89.5
14	D	15.5	8.8	10.2	65.4
15	D	3.1	17.5	3.9	75.5
16	B	7.7	79.3	2.7	10.3
17	D	10.5	2	24.6	62.7
18	A	67.6	7.8	8.4	16.1
19	C	2	15.7	78.5	3.9
20	A	46.4	33.8	10.7	8.8
21	B	11.6	76	7.9	4.2
22	C	9.2	5	75.7	10.1
23	B	4.1	88.6	5.5	1.5
24	B	18.7	36.6	15	29.4
25	C	26.6	9.6	42.2	21.5

Item	Answer	Responses			
		A	B	C	D
		%	%	%	%
26	C	5.1	6.2	85.1	3.5
27	C	31	12.9	22.3	33.5
28	B	8.3	42.8	25.4	23.4
29	B	0.6	96.7	1.3	1.3
30	C	13.4	12.1	69.7	4.3
31	C	0.7	41.9	53.3	4.1
32	B	5.5	38.6	32.9	22.9
33	D	14.8	5.4	4.6	75.3
34	B	9.6	72.4	3.8	14.2
35	B	4	74.8	15.7	5.4
36	C	9.3	8.6	42.4	39.6
37	D	5.6	27.5	10.3	56.6
38	D	21	3.6	2.2	73
39	A	31.5	36.8	22.5	9
40	B	47.3	17.5	8.6	26.6
41	A	89	1.5	8.3	1.1
42	D	26.9	9.7	15.4	47.7
43	A	72.1	8.7	4.3	14.9
44	D	14.9	5.8	23.2	55.9
45	A	69.2	6.1	7.6	16.9
46	C	9.2	11.9	70.4	8.3
47	A	84	12.3	1.2	2.5
48	B	11.1	76	5.1	7.8
49	B	18.7	70.5	5.8	4.6
50	D	18.5	21.6	45.8	13.4

NOTE: Percentages may not add to 100% due to multiple responses or missing values.

TABLE 2
CHEMISTRY 3202 ITEM ANALYSIS
CONSTRUCTED RESPONSE (PART II)

Item	Students Completing Item	Value	Average
51.(a)	1958	4	3.0
51.(b)	1958	4	3.1
51.(c)	1958	3	2.1
51 .(d)	1958	2	1.3
52.(a)	1958	2	1.0
52.(b)	1958	4	2.3
52.(c)	1958	2	0.6
52.(d)	1958	4	2.0
52.(e)	1958	2	1.2
53.(a)	1958	5	2.8
53.(b)	1958	4	3.4
53.(c)	1958	4	2.3
54.(a)	1958	3	1.9
54.(b)	1958	4	2.2
54.(c)	1958	3	2.1