

Grading Standards Chemistry 3202 June 2009

Pre-Marking Appraisal

The examination was considered fair and rigidly adhered to the examination Table of Specifications.

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 went down from June 2008 to June 2009, but was the second highest provincial score in the past five years. 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

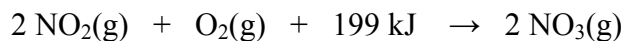
Part I - Selected Response - Total Value: 50%

- Item #9: Students did not read the question carefully. Many students chose an answer as though the equilibrium was shifting left.
- Item #13: Students did not recognize that the unknown could not have been an acid; it did not react with Mg.
- Item #14: Students confused the Arrhenius definition of a base with the Bronsted-Lowry definition.
- Item #23: Students did not recognize that the base, NaOH, will react with the acid, HF, in the equilibrium equation given.
- Item #24: Students confused the definition of equivalence point with the definition of endpoint.
- Item #33: Students confused the difference in endothermic and exothermic processes and the effect they have on their surroundings.
- Item #40: Many students did not use the bond energy formula correctly. They added 184.6 kJ (the ΔH for the reaction) to the product bond energy and then subtracted the reactant bond energy.
- Item #45: Many students did not appear to recognize that Choice C was not balanced in terms of charge; 6 negative on the left and 6 positive on the right.
- Item #46: Students showed poor understanding of direction of electron flow and ion flow.
- Item #48: Some students did not appear to understand the reaction that would take place in the cell described.

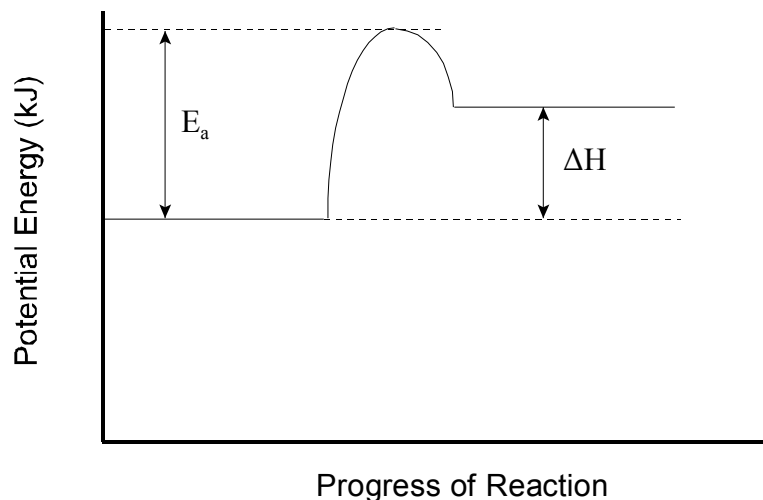
Part II - Constructed Response - Total Value: 50%

Value

- 2% 51.(a) The reaction below has an activation energy of 209 kJ. Sketch a potential energy diagram for the reaction, and label the activation energy and heat of reaction.



1 mark **shape**
½ mark **E_a**
½ mark **ΔH**



Common Errors

Students:

- drew an exothermic shape.
- thought ΔH was from products to top of graph; ie: E_a (rev).
- labeled E_a as ΔH and ΔH as E_a .

Value

- 2% 51.(b) For the reaction below, it takes longer to collect 35 mL of CO₂(g) using acid at room temperature compared to acid at 60.0 °C. Explain why.



1 mark Room Temp is a lower temp, thus molecules are moving slower than those at 60°C, thus they collide less often and with less intensity.

1 mark So there are fewer successful collisions having the activation energy and proper orientation thus taking longer.

*** Explained from the higher temp perspective acceptable as well.**

Common Errors

Students:

- used equilibrium for their explanation.
- did not include “increase in intensity” of collisions.
- did not include “results in more successful collisions” – or more collisions with the E_a and proper orientation.

Value

2% 51.(c) Using collision theory, explain why zinc metal reacts more rapidly in concentrated HCl(aq) than in dilute HCl(aq).

½ mark Concentrated HCl has more reactant particles.

1 mark More reactant particles means there are more collisions.

More collisions means more will be successful having the activation energy

½ mark and proper orientation, thus reacting more rapidly.

Common Errors

Students:

- did not include more particles because of greater concentration.
- did not include “results in more successful collisions” – or more collisions with the E_a and proper orientation.

Value

- 2% 51.(d) Inside a propane tank, the equilibrium below is created. When propane gas is released from the tank, explain why condensation forms on the outside of the tank.



1 mark According to LCP, removal of $\text{C}_3\text{H}_8(\text{g})$ causes the equilibrium to try to replace it by shifting to the right, thus absorbing energy from the surroundings (tank).

1 mark The decreasing temperature of surroundings (tank) will cause water vapour outside of the tank to condense on its cold surface.

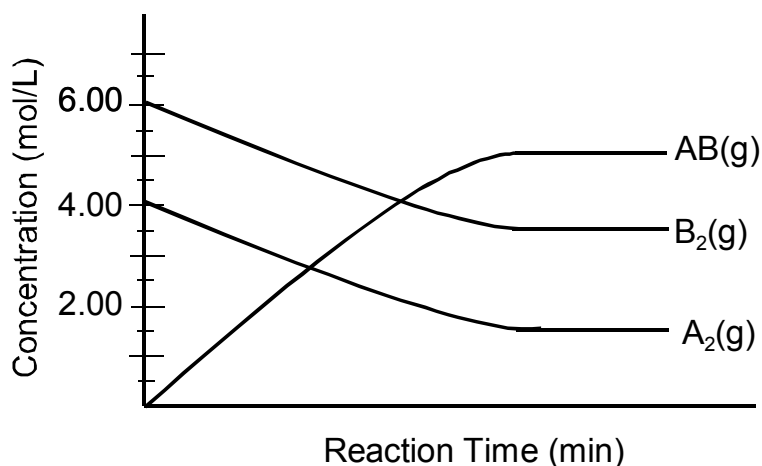
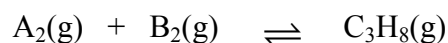
Common Errors

Students:

- did not identify the question as an equilibrium question (shift right – absorbing heat from the surroundings).
- confused the direction of shift.

Value

- 2% 51.(e) For the reaction below, the graph shows how $A_2(g)$ and $B_2(g)$ come to equilibrium with $AB(g)$ at constant temperature in a 1.0 L flask. Calculate the equilibrium constant.



1 mark **Equilibrium values from the graph:**

$$[A_2]_{eq} = 1.50 \text{ mol/L}$$

$$[B_2]_{eq} = 3.50 \text{ mol/L}$$

$$[AB]_{eq} = 5.00 \text{ mol/L}$$

½ mark $K = \frac{[AB]^2}{[A_2][B_2]} = \frac{(5.00)^2}{(1.50)(3.50)}$

½ mark $= 4.76$

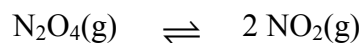
Common Errors

Students:

- read incorrect equilibrium concentrations off the graph.
- attempted to determine equilibrium concentrations from initial concentrations and an ICE table.

Value

- 3% 51.(f) Calculate K_{eq} if 1.0 mol of N_2O_4 is initially placed into a 1.0 L vessel, and at equilibrium 0.75 mol of N_2O_4 remains in the vessel.



$\frac{1}{2}$ mark

I	1.0 mol/L		0
C	$-x$		$+ 2x$
E	0.75 mol/L		$2x$

1 mark

$$x = [N_2O_4]_{\text{change}} = 1.0 \text{ mol/L} - 0.75 \text{ mol/L} = 0.2(5) \text{ mol/L}$$

$\frac{1}{2}$ mark

$$[NO_2]_{eq} = 2x = 2 (0.2(5)\text{mol/L}) = 0.5 \text{ mol/L}$$

$\frac{1}{2}$ mark

$$K = \frac{[NO_2]^2}{[N_2O_4]} = \frac{(0.5)^2}{(0.75)}$$

$\frac{1}{2}$ mark

$$= 0.3$$

Common Errors

Students:

- identified 'x', as 0.75 mol/L, instead of $1.0 - 0.75 = 0.25$ mol/L.
- did not multiply 'x' by 2 to get the equilibrium concentration of NO_2 .

Value

4% 52.(a) Calculate the pH of a 0.25 mol/L solution of NH_3 ($K_b = 1.8 \times 10^{-5}$).

$\frac{1}{2}$ mark

	NH_3	$+$	H_2O	\rightleftharpoons	OH^-	NH_4^+
I	0.25				0	0
C	$-x$				$+x$	$+x$
E	$0.25 - x$				$+x$	$+x$

$\frac{1}{2}$ mark

$\frac{1}{2}$ mark Check: $\frac{[\text{NH}_3]_i}{K_b} = \frac{0.25}{1.8 \times 10^{-5}} = 13888 > 500$

$\frac{1}{2}$ mark

Thus assume $0.25 - x \sim 0.25$

$$K = \frac{[\text{OH}^-][\text{NH}_4^+]}{[\text{NH}_3]}$$

$\frac{1}{2}$ mark

$$1.8 \times 10^{-5} = \frac{x^2}{0.25}$$

$\frac{1}{2}$ mark

$$x = 2.1(2) \times 10^{-3} = [\text{OH}^-]$$

$\frac{1}{2}$ mark

$$\text{pOH} = -\log [\text{OH}^-] = -\log 2.1(2) \times 10^{-3} = 2.67$$

$\frac{1}{2}$ mark

$$\text{pH} = 14.000 - \text{pOH} = 14.000 - 2.67 = 11.33$$

Common Errors

Students:

- used the wrong reaction ie: $\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_2^- + \text{H}_3\text{O}^+$ or no reaction.
- used 0.25 mol/L as the $[\text{OH}^-]$ or $[\text{H}_3\text{O}^+]$.
- did not check the assumption.
- used $\text{pOH} = -\log K_b$.
- used $[\text{OH}^-] = (K_b)(0.25)$.

Value

- 4% 52.(b) Calculate the concentration of a 10.00 mL CH₃COOH solution using the data provided from the standardization with a 0.1404 mol/L NaOH solution.

Burette	Trial 1	Trial 2	Trial 3
Final (mL)	16.90	32.02	47.18
Initial (mL)	1.35	16.90	32.02
Volume NaOH used (mL)	15.55	15.12	15.16

$\frac{1}{2}$ mark Average Volume of NaOH = $\frac{15.12 + 15.16}{2} = 15.14$ mL



$\frac{1}{2}$ mark n (NaOH) = c × v = (0.1404 mol/L) (0.01514) = 0.002125(7) mol

$\frac{1}{2}$ mark n (CH₃COOH) = 0.002125(7) mol × $\frac{1 \text{ mol CH}_3\text{COOH}}{1 \text{ mol NaOH}}$
= 0.002125(7) mol

1 mark c = $\frac{n}{v} = \frac{0.002125(7) \text{ mol}}{0.01000 \text{ L}} = 0.2126 \text{ mol/L}$

Science Communication $\frac{1}{2}$ mark units $\frac{1}{2}$ mark significant figures

Common Errors

Students:

- averaged all three volumes, instead of two values, within 0.10 mL.
- used incorrect formulae; C = nV or n = C/V.
- used the dilution formula: C_i V_i = C_f V_f .
- did not show 1:1 mole ratio.

Value

- 4% 52.(c) A solution is prepared by dissolving a 15.00 g sample of an alkali metal hydroxide, MOH(s), in enough water to make a 5.00 L solution. If the resulting pH is 12.466, identify the metal, M.



$\frac{1}{2}$ mark $\text{pOH} = 14.000 - 12.466 = 1.534$

$\frac{1}{2}$ mark $[\text{OH}^-] = 10^{-\text{pOH}} = 10^{-1.534} = 0.0292(4) \text{ mol/L}$

$\frac{1}{2}$ mark $n_{(\text{OH}^-)} = c v = (0.0292(4) \text{ mol/L}) (5.00 \text{ L}) = 0.146(2) \text{ mol}$

$\frac{1}{2}$ mark $n_{(\text{MOH})} = n_{(\text{OH}^-)} \text{ (Ratio 1:1)}$

$\frac{1}{2}$ mark $M_{(\text{MOH})} = \frac{m}{n} = \frac{15.00 \text{ g}}{0.146(2) \text{ mol}} = 102.6 \text{ g/mol}$

$\frac{1}{2}$ mark $M_{(\text{M})} = M_{(\text{MOH})} - M_{(\text{OH}^-)}$
 $= 102.6 \text{ g/mol} - 17.01 \text{ g/mol}$
 $= 85.6 \text{ g/mol}$

1 mark **M is Rb; rubidium.**

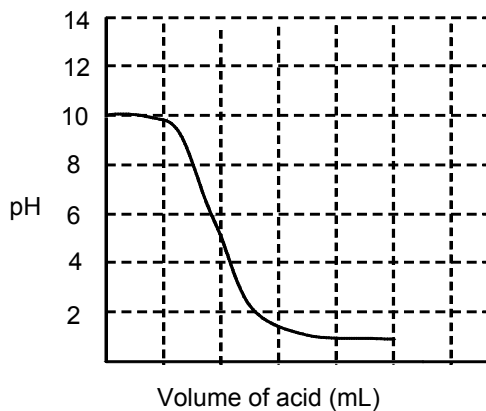
Common Errors

Students:

- did not include mole ratio.
- did not subtract the molar mass of OH^- from the calculated molar mass.
- calculated the $[\text{H}_3\text{O}^+]$, but not $[\text{OH}^-]$.
- tried to use an ICE table.
- re-arranged the formulae, $c = n/v$ and $n = m/M$, incorrectly.
- did not choose an alkali metal.
- did not attempt even part of the question.

Value

- 2% 52.(d) A base is titrated with a strong acid to produce the graph below. Explain whether the base is strong or weak.



1 mark The base is weak.

1 mark This is because the pH at the equivalence point is less than 7.

Common Errors

Students:

- referred to the starting pH of the graph as the explanation, rather than the equivalence point.
- did not read the question carefully and discussed acid strength or suggested indicators for the titration.

Value

- 2% 53.(a) A 100.0 g chocolate bar ($\text{C}_7\text{H}_8\text{N}_4\text{O}_2$) is burned in a bomb calorimeter that has a heat capacity of $6.50 \text{ kJ/}^\circ\text{C}$. Calculate the molar heat of combustion of the chocolate bar if the temperature of the calorimeter and its contents increases from 21.90°C to 27.40°C .

1 mark

$$\begin{aligned} q(\text{system}) &= -q(\text{surroundings}) \\ q(\text{chocolate}) &= -q(\text{calorimeter}) \\ &= -(C \Delta T) \\ &= -[6.50 \text{ kJ/}^\circ\text{C} (27.40^\circ\text{C} - 21.90^\circ\text{C})] \\ &= -[(6.50 \text{ kJ/}^\circ\text{C}) (5.50^\circ\text{C})] \\ &= -35.7(5) \text{ kJ} \end{aligned}$$

½ mark

$$n(\text{C}_7\text{H}_8\text{N}_4\text{O}_2) = \frac{m}{M} = \frac{100.0 \text{ g}}{180.19 \text{ g/mol}} = 0.5549(7) \text{ mol}$$

½ mark

$$\Delta H_{\text{comb}} = \frac{q}{n} = \frac{-35.7(5) \text{ kJ}}{0.5549(7) \text{ mol}} = -64.4 \text{ kJ/mol}$$

Common Errors

Students:

- used $q = mc\Delta T$ instead of $q = C\Delta T$ for the calorimeter.
- did not use 1st Law of Thermodynamics, ie: $q_{\text{system}} = -q_{\text{surroundings}}$.
- used $6.50 \text{ kJ/}^\circ\text{C}$ as 'q', not 'C'.
- converting from kJ to J incorrectly.
- used $q = mc\Delta T$ instead of $q = n\Delta H$ for the chocolate bar.

Value

- 4% 53.(b) A mixture of 125.0 g of an unreactive metal and 250.0 g of water has a temperature of 25.0 °C. The mixture is heated to a final temperature of 70.0 °C. Calculate the specific heat capacity of the metal if the mixture absorbs 49.7 kJ of heat.

$\frac{1}{2}$ mark $\Delta T = 70.0\text{ }^{\circ}\text{C} - 25.0\text{ }^{\circ}\text{C} = 45.0\text{ }^{\circ}\text{C}$

$$\begin{aligned} q(\text{absorbed}) &= -q(\text{gain}) \\ &= -[q_{\text{metal}} + q_{\text{water}}] \\ -49.7\text{ kJ} &= -[(125.0\text{ g} \times c \times 45.0\text{ }^{\circ}\text{C}) + (250.0\text{ g} \times 4.184\text{ J/g}^{\circ}\text{C} \times 45.0^{\circ})] \\ -49700\text{ J} &= -[(562(5) \times c) + 470(70)] \\ -49700\text{ J} &= -562(5)c - 470(70) \end{aligned}$$

1 mark $q(\text{absorbed})$ side
2 marks $-q(\text{gain})$ side

$\frac{1}{2}$ mark $c = \frac{-49700\text{ J} + 470(70)}{-562(5)} = \frac{-26(30)}{-562(5)} = 0.47\text{ J/g}^{\circ}\text{C}$

Common Errors

Students:

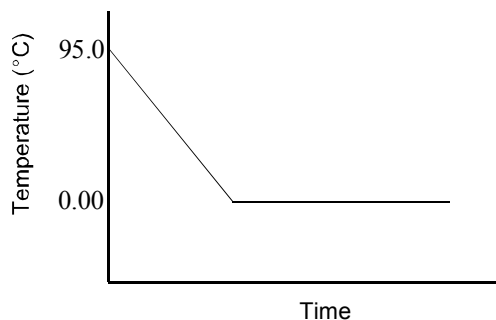
- added masses together and solved for 'c'.
- set $q_{\text{metal}} = -q_{\text{water}}$, and then solved for c_{metal} .
- calculated ΔT incorrectly.
- did not calculate ΔT ... used 25°C for the metal and 70°C for the water.
- used 125.0 g as the mass of water.
- did not recognize that both the metal and the water absorbed energy.

Value

5% 53.(c) A 2.50 g sample of water is cooled from 95.0 °C to 0.00 °C and is completely frozen.

i) Draw the cooling curve for this process.

1 mark



ii) Calculate the energy released by the water sample.

1 mark

$$q_1 = mc_{\text{water}}\Delta T = (2.50 \text{ g}) (4.184 \text{ J/g}\cdot^\circ\text{C}) (0.00^\circ\text{C} - 95.0^\circ\text{C}) = -993.(7) \text{ J}$$

1 mark

$$q_2 = n \Delta H^\circ_{\text{solid}} = \frac{2.50 \text{ g}}{18.02 \text{ g/mol}} \times -6.02 \text{ kJ/mol} = -0.835(2) \text{ kJ}$$

1 mark

$$\Delta E_{\text{total}} = -993.(7) \text{ J} + (-835.(2) \text{ J}) = -1829 \text{ J}$$

Science Communication ½ mark units ½ mark significant figures

Common Errors**53.(c) part i)**

Students:

- showed too many energy changes.
- adding in a boiling point and/or melting point at 25°C.
- drew a curve as if it was a reaction mechanism.

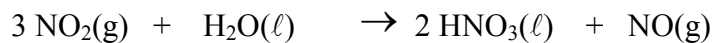
53.(c) part ii)

Students:

- did not convert one of the calculated 'q' values from kJ to J (or vice versa).
- performed sign errors; all values were not negative.
- calculated only one of the energy changes (either the temp change or phase change).
- used 40.7 kJ/mol instead of 6.02 kJ/mol for ΔH .
- did not use the addition rule for significant figures correctly; science communication mark.

Value

2% 53.(d) Calculate the enthalpy change for the reaction below.



Substance	ΔH_f° (kJ/mol)
$\text{HNO}_3(\ell)$	-174.1
$\text{H}_2\text{O}(\ell)$	-285.8
$\text{NO}(\text{g})$	91.3
$\text{NO}_2(\text{g})$	33.2

$$\Delta H = \Sigma n \Delta H_f^\circ (\text{products}) - \Sigma n \Delta H_f^\circ (\text{reactants})$$

1 mark

$$= [(2 \text{ mol} \times -174.1 \text{ kJ/mol}) + (1 \text{ mol} \times 91.3 \text{ kJ/mol})]$$
$$- [(3 \text{ mol} \times 33.2 \text{ kJ/mol}) + (1 \text{ mol} \times -285.8 \text{ kJ/mol})]$$

1 mark

$$= [-348.2 + 91.3] - [99.6 \text{ kJ} + (-285.8)]$$
$$= [-256.9] - [-186.2]$$
$$= -70.7 \text{ kJ}$$

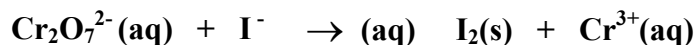
Common Errors

Students:

- used the bond energy equation instead of molar enthalpy of formation equation.
- did not multiply the ΔH_f° value by the molar coefficient.
- multiplied reactant and/or product values together instead of adding.

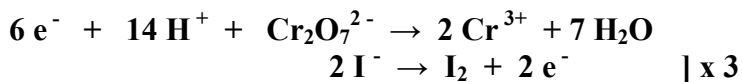
Value

4% 54.(a) Balance the redox reaction below under basic conditions.

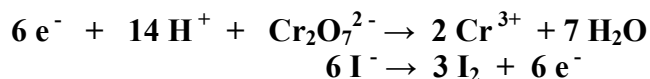


1 mark

½ mark

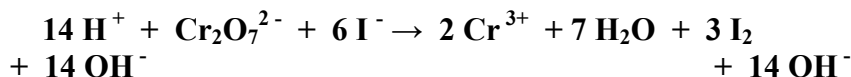


½ mark

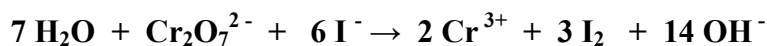


½ mark

½ mark



1 mark

**Common Errors**

Students:

- did not balance I properly and/or did not balance Cr properly.
- did not balance electrons.
- stopped after balancing under acidic conditions.
- did not cancel water molecules on both sides of the equation in the final answer.

Value

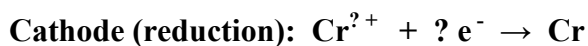
- 3% 54.(b) The chromium cathode in an electrolytic cell increases in mass by 1.37 g in 25.5 minutes at a current of 5.00 A. Calculate the charge on the chromium ion in solution.

$\frac{1}{2}$ mark $t = (25.5 \text{ min}) (60 \text{ s/min}) = 1530 \text{ s}$

$\frac{1}{2}$ mark $Q = I t = (5.00 \text{ A}) (1530 \text{ s}) = 7650 \text{ C}$

$\frac{1}{2}$ mark $n(e^-) = \frac{Q}{F} = \frac{7650 \text{ C}}{96500 \text{ C/mol } e^-} = 0.0792(7) \text{ mol } e^-$

$\frac{1}{2}$ mark $n(\text{Cr}) = \frac{m}{M} = \frac{1.37 \text{ g}}{52.00 \text{ g/mol}} = 0.0263(5) \text{ mol}$



$\frac{1}{2}$ mark $? = \frac{0.0792(7) \text{ mol } e^-}{0.0263(5) \text{ mol}} = 3$

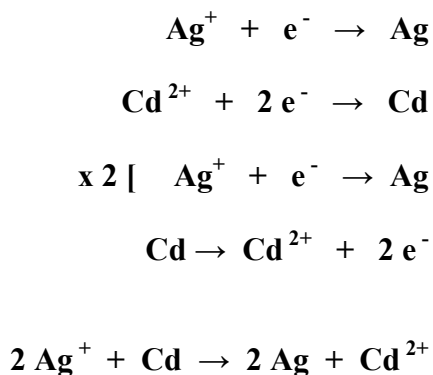
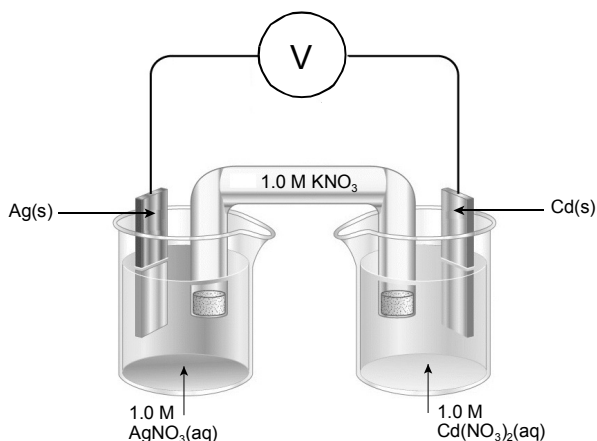
**Common Errors**

Students:

- did not change minutes to seconds.
- did not calculate the number of moles of Cr from the mass.
- let moles of Cr = moles of electrons.
- did not recognize that the question asked for ion charge, not 'Q'.

Value

- 3% 54.(c) Give the overall cell reaction and calculate the standard cell potential for the cell below.



1 mark

$$E^\circ = +0.80 \text{ V}$$

$$E^\circ = -0.40 \text{ V} \quad (\text{make ox for spontaneous rxn})$$

$$E^\circ = +0.80 \text{ V}$$

$$E^\circ = +0.40 \text{ V}$$

$$E^\circ_{\text{cell}} = 1.20 \text{ V}$$

1 mark

Science Communication $\frac{1}{2}$ mark units $\frac{1}{2}$ mark significant figures

Common Errors

Students:

- appeared to choose Ag as the anode because it was on the left of the diagram; confusing it with cell notation.
- did not write half reactions, thus did not balance electrons correctly to have an overall balanced reaction.
- did not write the overall reaction.
- did not have 3 significant figures (ie: 2 decimal places) for final answer.
- did not include units in final answer.

**CHEMISTRY 3202 ITEM ANALYSIS
SELECTED RESPONSE (PART I)**

Item	Answer	Responses			
		A	B	C	D
		%	%	%	%
1	B	1.6	92.5	5.4	0.4
2	A	85.4	3.8	6.7	4.1
3	D	3.1	14.2	6.3	76.4
4	B	7.7	78.4	4.1	9.8
5	D	2.2	0.9	0.5	96.5
6	B	6.3	92.8	0.4	0.5
7	B	12.8	53.0	24.4	9.6
8	A	91.4	5.2	2.3	1.0
9	C	14.6	22.6	40.5	22.0
10	B	26.9	59.5	8.3	5.3
11	D	5.3	0.2	0.5	94.0
12	B	9.3	77.7	10.6	2.3
13	D	43.1	19.1	14.4	23.3
14	D	33.2	4.7	12.3	49.6
15	B	13.2	76.2	6.2	4.3
16	D	0.6	3.0	1.1	95.3
17	B	12.2	56.0	15.6	15.9
18	A	70.3	5.0	18.5	6.0
19	D	4.7	10.5	4.1	80.7
20	B	12.3	85.3	1.4	1.1
21	B	14.0	75.5	9.8	0.7
22	D	11.1	2.1	2.8	83.9
23	B	16.5	27.6	22.1	33.7
24	B	10.6	67.3	16.2	5.2
25	C	5.5	2.7	79.5	12.3

Item	Answer	Responses			
		A	B	C	D
		%	%	%	%
26	C	28.8	32.7	32.2	6.3
27	A	94.5	0.9	3.3	1.3
28	D	10.8	19.8	15.3	54.0
29	B	1.0	89.4	8.0	1.6
30	D	6.1	7.7	3.4	82.8
31	D	13.3	10.6	4.8	71.2
32	C	3.9	5.1	90.2	0.8
33	A	42.6	37.8	13.1	6.4
34	C	14.4	11.1	67.0	7.4
35	D	8.5	10.7	11.1	69.8
36	B	9.7	81.7	6.4	2.2
37	A	68.3	8.1	7.9	15.5
38	A	55.3	22.1	18.9	3.8
39	B	3.1	75.5	8.2	13.1
40	A	37.7	10.2	9.2	42.7
41	A	86.8	9.0	2.8	1.4
42	C	6.5	12.2	63.1	18.0
43	B	23.6	52.6	18.7	4.9
44	B	13.4	66.5	13.3	6.8
45	D	18.0	10.0	28.1	43.8
46	D	8.7	37.2	22.3	31.7
47	D	13.8	6.0	6.1	74.1
48	C	19.8	20.5	43.8	15.5
49	B	9.7	72.4	13.3	4.6
50	A	60.4	9.0	7.4	23.2

**CHEMISTRY 3202 ITEM ANALYSIS
CONSTRUCTED RESPONSE (PART II)**

Item	Students Completing Item	Value	Average
51.(a)	1835	2	1.6
51.(b)	1835	2	0.9
51.(c)	1835	2	1.2
51.(d)	1835	2	0.4
51.(e)	1835	2	1.5
51.(f)	1835	3	2.2
52.(a)	1835	4	2.3
52.(b)	1835	4	2.2
52.(c)	1835	4	1.6
52.(d)	1835	2	1.3
53.(a)	1835	2	1.3
53.(b)	1835	4	1.8
53.(c)	1835	5	3.0
53.(d)	1835	2	1.4
54.(a)	1835	4	2.2
54.(b)	1835	3	1.5
54.(c)	1835	3	1.6