CHEMISTRY
UNIT 3
2022

MARKING GUIDE

GENERAL:
* MAX-BOLTZMAN DIST.
* USE of TERM "AMOUNT" (conc°/vol/mol)
* ANSWER SAC. ANODE Q.

Q9 (b) MISLEADING -1

Q31 (a) CURVES -1
Eq -1

Q33 (b) CONSIDER REMOVING -1
FROM REQ. TO -1
CONSIDER COLOUR
DUE TO CONC^N. (-1)?

Q34 (a) CURRENT FOR AIRLINE NOT ON SYLLABUS FOR RECALL
(b) TOO MANY -1
EXAMPLES FOR
RECALL ON THIS
TOPIC (-1)?

TIME ALLOWED FOR THIS PAPER
Reading time before commencing work: Ten minutes
Working time for the paper: Three hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

To be provided by the supervisor:
This Question/Answer Booklet
Multiple-choice Answer Sheet
Chemistry Data Book

Q35 (f) ("COLLISION THEORY")
OX. PT. VALUE
CURVE OUTSIDE OF -1
SYLLABUS

(g) CONTENT NOT ON
+h SYLLABUS - THIS -4
ONE GOT PAST
ME!

To be provided by the candidate:
Standard items: pens, pencils, eraser or correction fluid, ruler, highlighter.

Special items: calculators satisfying the conditions set by the SCSA for this subject.

Q36 (c) TOO MANY RR -1
ABS. Q.
(f) -1 IGN. OH- MECH.

IMPORTANT NOTE TO CANDIDATES
No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Q

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One Multiple-choice	25	25	50	25	25
Section Two Short answer	9	9	60	73	35
Section Three Extended answer	5	5	70	85	40
				Total	100

Section One: Multiple-choice **25% (25 marks)**

1	a □	b ■	c □	d □	6	a □	b ■	c □	d □	11	a ■	b □	c □	d □
2	a □	b □	c □	d ■	7	a □	b ■	c □	d □	12	a □	b □	c □	d ■
3	a □	b □	c □	d ■	8	a □	b ■	c □	d □	13	a □	b □	c □	d ■
4	a □	b □	c ■	d □	9	a ■	b □	c □	d □	14	a □	b □	c ■	d □
5	a □	b ■	c □	d □	10	a □	b □	c ■	d □	15	a □	b □	c □	d ■

16	a □	b □	c ■	d □	21	a ■	b □	c □	d □					
17	a □	b ■	c □	d □	22	a □	b □	c ■	d □					
18	a □	b □	c ■	d □	23	a □	b □	c □	d ■					
19	a ■	b □	c □	d □	24	a □	b ■	c □	d □					
20	a □	b □	c □	d ■	25	a □	b ■	c □	d □					

Section Two: Short answer **35% (73 marks)**

Question 26 * EASY → SLOW DOWN ON GRAPH READING **(8 marks)**

(a) State the value, including appropriate units, of (2 marks)

Description		Marks
(i)	-100 kJ mol^{-1}	1
(ii)	accept values in the range 125-135 kJ mol^{-1}	1
	Total	**2**

(b) Which reaction (A, B or C) is **not** a combustion reaction? Justify your choice. (2 marks)

Description	Marks
Reaction A	1
Any of the following justifications: • unlike reaction A, combustion reactions are always exothermic • unlike reaction A, combustion of a fuel will release heat energy • reaction A is the only endothermic reaction • in reaction A the value of ΔH is a positive value • in reaction A the enthalpy of the products is greater than the enthalpy of the reactants	1
Total	**2**

(c) Which reaction (A, B or C) represents combustion of the fuel with the lowest autoignition point? Justify your choice. (2 marks)

Description	Marks
Reaction B	1
Lowest (forward) activation energy	1
Total	**2**

(d) Which reaction (A, B or C) is most likely to be reversible? Justify your choice. (2 marks)

Description	Marks
Reaction A	1
Any of the following justifications: • lowest activation energy in both forward and reverse directions • combustion reactions (i.e. B and C) are not reversible	1
Total	**2**

Question 27 (10 marks)

MED → TERMINOLOGY FOR COLLISION THEORY
→ MAP OUT CALCULATIONS.

(a) Explain, in terms of the collision theory, why the batteries are crushed before being mixed with the leach solution. (3 marks)

Description	Marks
This will increase the surface area / state of subdivision (of the solid material),	1
resulting in an increased frequency of collisions with the leaching solution.	1
Thus the rate of reaction is increased.	1
Total	**3**

(b) Calculate the concentration of hydrogen peroxide, in grams per litre, that would be present in the leach solution after 5 hours. (7 marks)

Description			Marks
$m(LiCoO_2)$	=	(48.6/100) x 5.00	1
	=	2.43 g	
$n(LiCoO_2)$	=	2.43 / 97.87	1
	=	0.024829 mol	
$n(H_2O_2$ used)	=	(3/2) x 0.024829	1
	=	0.037243 mol	
$n(H_2O_2$ initial)	=	0.60 x 0.150	1
	=	0.09 mol	
$n(H_2O_2$ remaining)	=	0.09 – 0.037243	1
	=	0.052757 mol	
$m(H_2O_2$ remaining)	=	0.052757 x 34.016	1
	=	1.79457 g	
$c(H_2O_2$ remaining)	=	1.79457 / 0.15	1
	=	12 g L^{-1}	
Total			**7**

HIGH * STEP OUT OF CONTEXT AND THINK!
* COME BACK WITH TIME ~~LATER~~ LATER.

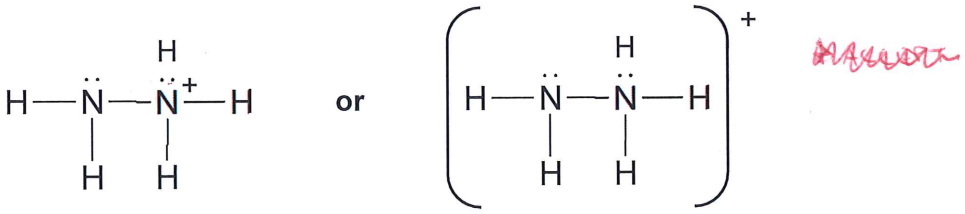
Question 28 **(7 marks)**

(a) Identify the feature of the hydrazine molecule that allows it to behave as a Brønsted-Lowry base. (1 mark)

Description	Marks
Non-bonding / lone pair of electrons (on the nitrogen atom)	1
Total	**1**

(b) Amend the Lewis diagram above, to represent the conjugate acid of hydrazine, which is named 'hydrazinium'. (2 marks)

ONLY 1 × H^+ FOR REACTION

Description	Marks
	
Addition of H on non-bonding electrons of either N atom	1
Positive charge shown (may be on N atom or outside of square brackets)	1
Total	**2**

(c) Write a balanced chemical equation showing the reaction between hydrazine and nitric acid, to form the salt hydrazinium nitrate. (2 marks)

Description	Marks
$N_2H_4(aq) + HNO_3(aq) \rightarrow N_2H_5NO_3(aq)$ **or** $N_2H_4(aq) + H^+(aq) \rightarrow N_2H_5^+(aq)$ **or** $N_2H_4(aq) + H_3O^+(aq) \rightarrow N_2H_5^+(aq) + H_2O(l)$	
Correct reactant species	1
Correct product species	1
Total	**2**
Note: state symbols are not required for full marks	

(d) Predict whether the resulting solution would be acidic, basic or neutral (circle your choice). Use a chemical equation to support your answer. (2 marks)

Description	Marks
Acidic (circled)	1
$N_2H_5^+(aq) + H_2O(l) \rightleftharpoons N_2H_4(aq) + H_3O^+(aq)$	1
Total	**2**
Note: state symbols are not required for full marks	

Question 29 EASY → SLOW DOWN + THINK → USE ATAR TERMINOLOGY → STRUCTURE ANSWER. **(7 marks)**

(a) Select a piece of data that supports the assertion 'AgBr(s) has a very low aqueous solubility'. Justify your answer. (2 marks)

Description	Marks
The K_c value for equation 1 is very small.	1
This indicates a very small concentration of each product is present, demonstrating the dissolution of AgBr occurs to a small extent.	1
Total	**2**

(b) Use Le Chatelier's principle, to describe how the introduction of thiosulfate ions assists in removing the silver bromide crystals from the photographic film. (5 marks)

Description	Marks
When the concentration of $S_2O_3^{2-}(aq)$ is increased, the system will act to decrease the concentration of $S_2O_3^{2-}(aq)$ ions.	1
Thus the forward reaction in equation 2 will be favoured. **or** Thus the equilibrium in equation 2 will shift to the right.	1
This will reduce the concentration of $Ag^+(aq)$ present,	1
therefore the forward reaction in equation 1 will also be favoured. **or** therefore the equilibrium in equation 1 will also shift to the right.	1
This decreases the amount of AgBr(s) present (and thus removes it from the photographic film).	1
Total	**5**

Question 30 MED/HIGH – TAKE ALL INFO FROM Q. – DIFF. TO FIT MARK MORE. **(6 marks)**

(a) Write a balanced equation for this half-reaction, and suggest a value for the associated standard reduction potential. (4 marks)

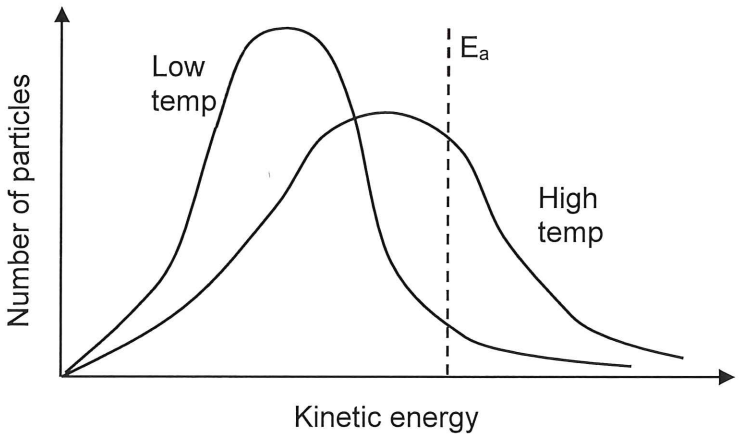
Description	Marks
Half-reaction $H_2SeO_4(aq) + 2\ H^+(aq) + 2\ e^- \rightleftharpoons H_2SeO_3(aq) + H_2O(l)$ **or** $SeO_4^{2-}(aq) + 4\ H^+(aq) + 2\ e^- \rightleftharpoons H_2SeO_3(aq) + H_2O(l)$	
Correct species	1
Correct balancing	1
E^0 value Any value between (but not including) +1.36 V and +1.51 V	
Value within acceptable range	1
Correct units	1
Total	**4**

(b) Justify whether selenic acid could be prepared by reacting acidified sodium dichromate solution with selenous acid, under standard conditions. (2 marks)

Description	Marks
The reduction potential of dichromate (+1.36 V) is lower than that of selenic acid, H_2SeO_4. **or** The reduction potential of selenic acid, H_2SeO_4, is higher than that of dichromate (+1.36V). **or** The oxidation potential of selenous acid is lower than -1.36 V.	1
Thus dichromate is not a strong enough oxidant to oxidise selenous acid / to produce selenic acid. **or** Thus the cell potential will have a negative value, indicating the reaction will not occur.	1
Total	**2**

Question 31 (9 marks)

(a) Explain why a decrease in temperature will decrease the rate of a reaction. Sketch a labelled kinetic energy distribution (Maxwell-Boltzmann) diagram to support your answer. (6 marks)

Description	Marks
(A decrease in temperature results in) a decrease in the average kinetic energy of particles.	1
This will decrease the frequency of successful collisions,	1
in addition to decreasing the proportion of successful collisions.	1
	
Correct shape of high and low temperature curves	1
Curves labelled to indicate higher / lower temperature	1
Activation energy indicated	1
Total	**6**

(b) Use the trend in the data to state the relationship between the variables. (1 mark)

Description	Marks
As the temperature decreases, the volume of $N_2O_3(l)$ increases.	1
Total	**1**

(c) Identify two (2) ways in which the students should improve the graphical representation of their data. (2 marks)

Description	Marks
Variables are on the incorrect axes / Axis labels need to be switched	1
A line of best fit should be used	1
Total	**2**

Question 32 (9 marks)

(a) Write an equation for the buffer solution that would be formed. (2 marks)

Description	Marks
$HPO_4^{2-}(aq) + H_2O(l) \rightleftharpoons H_2PO_4^-(aq) + OH^-(aq)$ **or** $HPO_4^{2-}(aq) + H_3O^+(aq) \rightleftharpoons H_2PO_4^-(aq) + H_2O(l)$	
Correct species	1
Double arrow shown in equation	1
Total	**2**
Note: state symbols are not required for full marks	

(b) Which buffer (A, B or C) would demonstrate the highest buffering capacity, if required to interact with both acidic and basic species? Justify your choice. (3 marks)

Description	Marks
Buffer B	1
It has the most similar concentrations of the conjugate acid-base pair, $HPO_4^{2-}(aq)$/ $H_2PO_4^-(aq)$.	1
Therefore will have the greatest ability to maintain pH upon addition of either acid or base.	1
Total	**3**

(c) Explain why Buffer A has the lowest pH. Use a relevant chemical equation to support your answer. (2 marks)

Description	Marks
$H_2PO_4^-(aq)$ is an acidic species and will hydrolyse in water to produce hydronium ions, $H_3O^+(aq)$	1
$H_2PO_4^-(aq) + H_2O(l) \rightleftharpoons HPO_4^{2-}(aq) + H_3O^+(aq)$	1
Total	**2**
Note: state symbols are not required for full marks	

(d) Identify the spectator ion present in this buffer, and state why it has no effect on the pH of the buffer. (2 marks)

Description	Marks
Potassium ions, $K^+(aq)$	1
$K^+(aq)$ ions do not hydrolyse in water, thus they are neutral.	1
Total	**2**

MARKED KINDLY.

Question 33 HARD : * COLOUR CHANGE DUE TO CONCENTRATION + NOT # mols (11 marks)

(a) Write the equilibrium constant expression (K) for this reaction. (2 marks)

Description	Marks
$K = \frac{[Br_2][F_2]^5}{[BrF_5]^2}$	
Products over reactants	1
Correct indices	1
Total	**2**

(b) Complete the following table, by predicting the observations for each time period. Provide a brief explanation for each observation. (9 marks)

Description	Marks
Initial	
Observations • Red-brown colour darkens.	1
Explanation • The concentration of Br_2 (and all other gases) has increased (resulting in the colour of Br_2 intensifying).	1
During shift	
Observations • Red-brown colour fades.	1
Explanation • The reverse reaction rate is increased relative to the forward reaction rate. • Thus the equilibrium shifts left, reducing the concentration of Br_2.	1 1
Final	
Observations • Red-brown colour remains constant. • Colour is darker than original equilibrium.	1 1
Explanation • The concentration of all species remains constant. • Since the change is only partially counteracted, the final concentration of Br_2 will still be higher than original.	1 1
Total	**9**

Question 34 **(6 marks)**

(a) Briefly describe the principles of cathodic protection. (3 marks)

Description	Marks
The steel/iron is connected to the negative terminal of a power source, ensuring it is the cathode.	1
An anode (commonly made of, for example, scrap iron metal or coated titanium) is connected and is the site of oxidation.	1
The current flows to the steel structure, ensuring it is protected / unable to oxidise.	1
Total	**3**

(b) By providing three (3) justifications, construct an argument that supports this statement. (3 marks)

Description	Marks
Any three justifications which identify either advantages of cathodic protection or disadvantages of powder coating.	3
Advantages of cathodic protection include: • provides good corrosion protection over long distances • provides good corrosion protection for larger structures • anodes are easily replaced Disadvantages of powder coating include: • if the coating was chipped/damaged this would be hard to see • if the coating was chipped/damaged this would be hard to repair • the coating could wear off over time • coating an entire pipeline would be expensive • there may be joins in the pipeline where the coating was not complete	
Total	**3**

Section Three: Extended answer **40% (85 marks)**

Question 35 **(19 marks)**

(a) Identify one (1) safety risk associated with this cell and one (1) safety measure to reduce this risk. (2 marks)

Description	Marks
Safety risk identified	1
Safety measure **related to** stated risk	1
Any of the following safety risks: • Chlorine gas is toxic • Hydrogen gas is explosive • Sodium hydroxide is caustic • Use of electrical current • Production of acidic / caustic waste streams Any related safety measure, including: • Ensure appropriate ventilation / ensure safe storage of chlorine • Ensure chlorine is not inhaled / wear gas mask / perform in fumehood etc • Keep sources of ignition away / ensure safe storage of hydrogen • Prevent contact with sodium hydroxide / wear gloves / wear protective clothing / wear glasses • Check electrical connections / ensure maintenance of electrical apparatus etc • Have a first aid kit and safety plan to treat sodium hydroxide burns • Ensuring appropriate steps are taken to minimise environmental impact of waste streams e.g. recycling waste water, removing acid / alkaline components from waste water etc	
Total	**2**

(b) Complete the table below, regarding the titanium and nickel electrodes in the membrane cell. (2 marks)

Description			Marks
	Designation of electrode	Polarity	
Titanium	anode	+	
Nickel	cathode	–	
Both anode and cathode correctly identified			1
Both polarities correctly identified			1
		Total	**2**
Note: mark each column individually, no follow through marks are awarded.			

(c) Provide a justification for the choice of titanium as the electrode material. (1 mark)

Description	Marks
Any of the following justifications: • It is unreactive and will not be oxidised • It will not corrode whilst submerged in salt solution • It is a metal and allows for the transfer of electrons	1
Total	**1**

(d) Explain why electrical energy needs to be provided for this cell to function. (2 marks)

Description	Marks
This reaction has a negative cell potential	1
and is therefore non-spontaneous (thus requiring electrical energy to drive the reaction to take place).	1
Total	**2**

(e) Calculate the final pH of the solution surrounding the nickel electrode. (5 marks)

Description			Marks
$n(Cl_2)$	=	(105 x 66.5) / (8.314 x 298.15)	1
	=	2.8169 mol	
$n(OH^-)$	=	2 x 2.8169	1
	=	5.6337 mol	
$c(OH^-)$	=	5.6337 / 12	1
	=	0.46948 mol L^{-1}	
$[H^+]$	=	$(1.0 \times 10^{-14}) / 0.46948$	1
	=	2.130×10^{-14} mol L^{-1}	
pH	=	$-\log(2.130 \times 10^{-14})$	1
	=	13.7	
		Total	**5**

(f) Describe why this $O_2(g)$ forms, using a relevant chemical equation to support your answer. Propose a reason why the amount of $O_2(g)$ produced decreases, as the concentration of NaCl(aq) increases. (3 marks)

Description	Marks
The $O_2(g)$ is formed from the (preferential) oxidation of water.	1
$2\ H_2O(l) \rightarrow O_2(g) + 4\ H^+(aq) + 4\ e^-$	1
As the concentration of NaCl(aq) increases; the value of the oxidation potential (for the oxidation of $Cl^-(aq)$) would change and this will affect which species is likely to be oxidised. **or** the concentration of chloride increases, and therefore there is more likely to be collisions between the $Cl^-(aq)$ ions and the anode.	1
Total	**3**
Note: state symbols are not required for full marks	

(g) Name one (1) product of the Downs process that is the same, and one (1) product that is different, to those produced in the chloralkali process. (2 marks)

Description	Marks
Chlorine (gas)	1
Sodium (metal)	1
Total	**2**

(h) Suggest two (2) reasons the Downs process requires a greater energy input than the chloralkali process. (2 marks)

Description	Marks
More (heat) energy would be required to maintain the electrolyte in a molten state in the Downs cell.	1
More (electrical) energy **or** a higher voltage would be required to drive the reaction to occur since the reaction has a more negative cell potential.	1
Total	**2**

Question 36 **(18 marks)**

(a) Explain, with the use of an equation, how the phosphate ion, $PO_4^{3-}(aq)$, contributes to the alkalinity of the water. (3 marks)

Description	Marks
Phosphate ions hydrolyse in water to produce $OH^-(aq)$.	1
$PO_4^{3-}(aq) + H_2O(l) \rightleftharpoons HPO_4^{2-}(aq) + OH^-(aq)$	1
Therefore the $[OH^-] > [H_3O^+]$, resulting in an alkaline solution.	1
Total	**3**
Note: state symbols are not required for full marks	

(b) Calculate the 'total alkalinity' of the river water sample, if the density of the river water was determined to be 1.024 kg L^{-1}. (5 marks)

Description			Marks
From titration curve, V(HCl titre)	=	13.20 mL	1
n(HCl in 100 mL)	=	0.01565 x 0.01320	1
	=	0.00020658 mol	
n(HCl in 1 L)	=	10 x 0.00020658	1
	=	0.0020658 mol	
n(HCl in 1 kg)	=	0.0020658 / 1.024	1
	=	0.002017 mol	
total alkalinity	=	0.002017 x 1000	1
	=	2.02 mmol	
Total			**5**
Note: accept titre values in the range 13.1-13.3 mL. This results in final values for total alkalinity being in the range 2.00-2.03 mmol.			

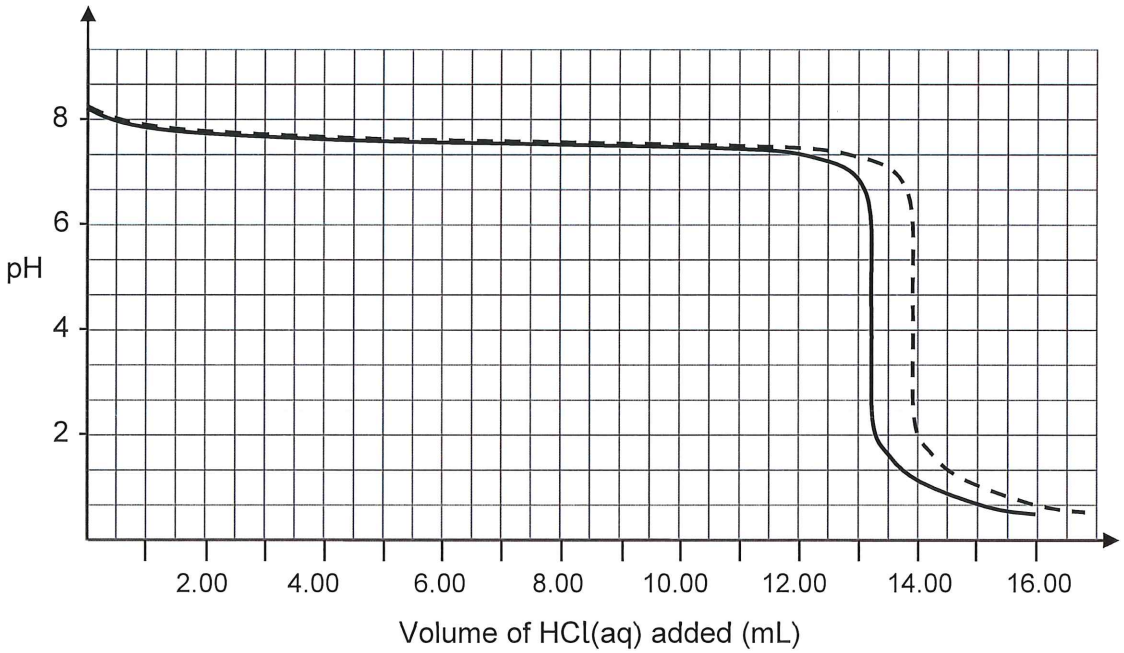
(c) Identify three (3) ways the students could increase the validity of their reported total alkalinity value. (3 marks)

Description	Marks
Any three appropriate suggestions, including: • Collect samples from different depths in the river • Collect samples from different locations along the river • Collect samples at different times of the day • Collect samples during different months / seasons	3
Total	**3**

(d) Explain why bromothymol blue would **not** be an appropriate indicator choice for this titration. (2 marks)

Description	Marks
The equivalence point for this reaction is acidic (occurring at approximately pH 4.2-4.5)	1
Therefore the end point / colour change of this indicator would occur too early (and lead to lower titre volumes)	1
Total	**2**

(e) If the students had incorrectly rinsed the burette with water; (2 marks)

Description	Marks
	
(i) curve is same shape as original, but indicates higher average titre (see dashed line above)	1
(ii) too high (circled)	1
Total	**2**

(f) Increased atmospheric $CO_2(g)$ levels result in sea water having a lower total alkalinity. By referring to the equations above, justify why lower total alkalinity corresponds to a decrease in carbonate ion concentration. (3 marks)

Description	Marks
(A lower total alkalinity) will result in a decreased $OH^-(aq)$ concentration.	1
This will shift the equilibrium position of equation 2 (and 3) to the right.	1
This will partially counteract the decrease in $OH^-(aq)$ concentration whilst lowering the concentration of $CO_3^{2-}(aq)$.	1
Total	**3**

Question 37 **(18 marks)**

(a) Explain the difference in gradient between the $N_2(g)$ and $O_2(g)$ curves, from Time A to B. (2 marks)

Description	Marks
The $N_2(g)$ is used up at half the rate of $O_2(g)$. **or** The $O_2(g)$ is used up at twice the rate of the $N_2(g)$.	1
This is because the stoichiometric ratio of $N_2(g)$ to $O_2(g)$ is 1:2 in the chemical equation.	1
Total	**2**

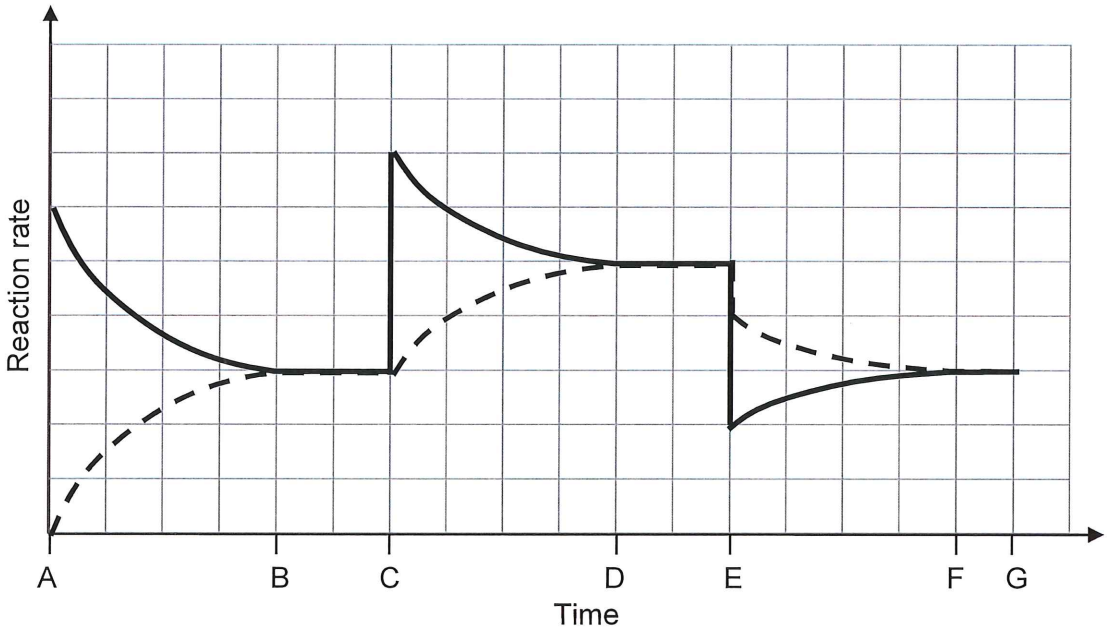
(b) Identify the change that occurred at Time C. (1 mark)

Description	Marks
$O_2(g)$ was injected into the system / The concentration of $O_2(g)$ in the system was increased.	1
Total	**1**

(c) At Time E, the temperature of the system was decreased. Is the reaction endothermic or exothermic as written? Justify your answer. (4 marks)

Description	Marks
The graph shows an increase in the concentration of reactants.	1
Therefore the reverse reaction must be favoured.	1
A temperature decrease favours the exothermic reaction (in order to produce more heat).	1
Thus the equation must be endothermic as written.	1
Total	**4**

(d) On the blank grid on the previous page, sketch a graph illustrating the changes in both the forward and reverse reaction rates that occurred in this system from Time A to G. Use a solid line (——) to represent the forward reaction rate and a dashed line (- - -) to represent the reverse reaction rate. (8 marks)

Description	Marks
	
From A to B Correct shape of curves Correct use of solid/dashed lines (i.e. forward higher than reverse)	 1 1
From C to D Correct shape of curves Correct use of solid/dashed lines (i.e. forward higher than reverse)	 1 1
From E to F Instantaneous decrease shown for both rates Correct shape of curves Correct use of solid/dashed lines (i.e. reverse higher than forward)	 1 1 1
From B to C, D to E, F to G Horizontal lines	 1
Total	**8**

(e) Provide a justification for the lack of reactivity between $N_2(g)$ and $O_2(g)$ at room temperature, given that the K_c value for this reaction is large. (3 marks)

Description	Marks
The reaction may have a high activation energy.	1
Therefore at room temperature the reactants do not have enough energy to overcome this barrier and form products.	1
A large K_c value does not indicate a fast reaction rate, it only indicates the position of equilibrium once established.	1
Total	**3**

Question 38 **(16 marks)**

(a) Is M(s) the anode or cathode in this cell? Justify your answer. (3 marks)

Description	Marks
Anode	1
Either of the following justifications; • Electrode M lost mass (to form metallic ions) • Therefore it must have been oxidised **or** • The pH of the HCl(aq) electrolyte increased • Therefore indicating reduction of $H^+(aq)$ (and therefore the platinum electrode is the cathode)	2
Total	**3**

(b) Write balanced half-equations for the reactions occurring in this cell. (2 marks)

Description		Marks
anode:	$M(s) \rightarrow M^{2+}(aq) + 2\ e^-$	1
cathode:	$2\ H^+(aq) + 2\ e^- \rightarrow H_2(g)$	1
	Total	**2**
Note: state symbols are not required for full marks		

(c) List two (2) quantitative pieces of data, that would allow the hydrogen half-cell to conform to 'standard conditions'. (2 marks)

Description	Marks
Any two of the following: • The $H_2(g)$ is at 100 kPa • The reactants are at 25 °C • The initial concentration of HCl(aq) is 1 mol L^{-1}	2
Total	**2**
Note: accept a pressure of 1 atm / 101.3 kPa, as standard reduction potential tables can differ in this regard.	

WORDING?

(d) Determine the identity of M(s). Show all workings. (9 marks)

V. HARD

BUT POINTS WERE THERE FOR THE TABLE.

Description			Marks
$[H^+ \text{ initial}]$	=	10^{-0}	1
	=	1 mol L^{-1}	
$[H^+ \text{ final}]$	=	$10^{-0.422}$	1
	=	0.37844 mol L^{-1}	
$n(H^+ \text{ initial})$	=	1 x 0.750	1
	=	0.750 mol	
$n(H^+ \text{ final})$	=	0.37844 x 0.750	1
	=	0.28383 mol	
$n(H^+ \text{ reacted})$	=	0.750 – 0.28383	1
	=	0.46617 mol	
n(M)	=	½ x $n(H^+)$	1
	=	0.23308 mol	
m(M lost)	=	91.3 – 65.2	1
	=	26.1 g	
M(M)	=	26.1 / 0.23308	1
	=	111.98 g mol^{-1}	
M is likely to be cadmium			1
		Total	**9**

Question 41 **(19 marks)**

(a) Calculate the mass of gold that was leached into solution. (6 marks)

Description		Marks
m(NaCN initial)	= 0.478 x 25000 = 11950 g	1
m(NaCN final)	= 0.083 x 25000 = 2075 g	1
m(NaCN reacted)	= 11950 - 2075 = 9875 g	1
n(NaCN)	= 9875 / 49.01 = 201.4895 mol	1
n(Au)	= (1/2) x 201.4895 = 100.7447 mol	1
m(Au)	= 100.7447 x 197 = 19847 g (2.0 x 10^4 g)	1
	Total	**6**

(b) Calculate the final pH of the leaching solution. (You may assume that only the $OH^-(aq)$ ions produced are contributing to pH). (4 marks)

Description		Marks
$n(OH^-)$	= 100.7447 mol	1
$c(OH^-)$	= 100.7447 / 25000 = 0.0040298 mol L^{-1}	1
$[H^+]$	= (1.0 x 10^{-14}) / 0.0040298 = 2.4815 x 10^{-12} mol L^{-1}	1
pH	= - log (2.4815 x 10^{-12}) = 11.6 (12)	1
	Total	**4**
Alternate working: pOH pH	= - log (0.0040298) = 2.3947 = 14 - 2.3947 = 11.6 (12)	

(c) State the oxidant and the reductant in this process. (2 marks)

Description	Marks
Oxidant: $Au(CN)_2^-$	1
Reductant: Zn	1
Total	**2**

(d) Explain, in terms of the collision theory, why zinc **dust** is used to precipitate the gold out of solution. (3 marks)

Description	Marks
The dust has a high surface area / high state of subdivision	1
This results in an increased frequency of collision,	1
and therefore a faster reaction rate	1
Total	**3**