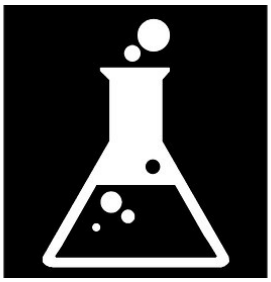
ROSSMOYNE SENIOR HIGH SCHOOL



CHEMISTRY
UNIT 3
2017

MARKING GUIDE

Section One: Multiple-choice **(50 marks)**

1	a ☐ b ☐ c ☐ d ■
2	a ☐ b ■ c ☐ d ☐
3	a ☐ b ☐ c ☐ d ■
4	a ☐ b ☐ c ■ d ☐
5	a ☐ b ■ c ☐ d ☐

11	a ☐ b ☐ c ■ d ☐
12	a ☐ b ☐ c ☐ d ■
13	a ☐ b ■ c ☐ d ☐
14	a ☐ b ☐ c ☐ d ■
15	a ☐ b ☐ c ☐ d ■

21	a ☐ b ☐ c ■ d ☐
22	a ■ b ☐ c ☐ d ☐
23	a ☐ b ☐ c ■ d ☐
24	a ☐ b ☐ c ■ d ☐
25	a ☐ b ☐ c ☐ d ■

6	a ☐ b ☐ c ■ d ☐
7	a ☐ b ☐ c ☐ d ■

16	a ☐ b ☐ c ■ d ☐
17	a ☐ b ☐ c ☐ d ■

8	a ☐ b ☐ c ■ d ☐	18	a ☐ b ☐ c ■ d ☐
9	a ☐ b ☐ c ■ d ☐	19	a ■ b ☐ c ☐ d ☐
10	a ☐ b ■ c ☐ d ☐	20	a ☐ b ☐ c ■ d ☐

(2 marks per question)

Section Two: Short answer **(70 marks)**

Question 26 **(4 marks)**

Write observations for any reactions that occur in the following procedures. In each case describe in full what you would observe, including any:

- colours
- odours
- precipitates (give the colour)
- gases evolved (give the colour or describe as colourless).

If no change is observed, you should state this.

(Note: No chemical equations necessary).

(a) Some chlorine gas is bubbled through a solution of sodium iodide (2 marks)

A pungent green yellow gas is bubbled through a clear solution and a brown solution is formed.

Max of 1 mark if students did not mention Cl gas is pungent

(*Must have three observations for both marks).

(b) Some solid copper (II) hydroxide is mixed with a dilute nitric acid solution. (2 marks)

A blue solid dissolves in a colourless solution to produce a blue solution.

(*Must have three observations for both marks).

Question 27 **(5 Marks)**

(a) Suggest (2 marks)

(i) An oxidising agent which could convert Fe to Fe^{2+} but not Sn to Sn^{2+}

Ni^{2+} OR Co^{2+} OR Cd^{2+} (must be the ion)

(ii) A reducing agent which could reduce Cr^{3+} to Cr but not Mg^{2+} to Mg

Zn OR Mn OR Al (must be the element)

One of the most significant consequences of ocean acidification is the effect that it has on shellfish and other marine life that produce calcium carbonate and relies on it as a major component of the exoskeleton or other supporting structure. If the water is sufficiently acidic, the carbonate structures may not form completely. Ocean acidification is thought to lead to a reduction in the availability of carbonate ions. Further reaction of the dissolved carbon dioxide occurs as shown below.

$$CO_2(g) + CO_3^{2-}(aq) + H_2O(l) \rightleftharpoons 2\,HCO_3^-(aq)$$

(b) Identify a conjugate acid-base pair in this reaction, and explain why it is classified as a Brønsted – Lowry acid-base reaction.

(3 marks)

Conjugate A/B pair = CO_3^{2-} / HCO_3^- (1) *Also accept HCO_3^- / CO_3^{2-}

This equation is classified as a Brønsted – Lowry acid-base reaction because in the forward reaction, H_2O donates a proton, thus acting as a B-L acid, (1)

while CO_3^{2-} accepts a proton, thus acting as a B-L base. (1)

Question 28 **(6 Marks)**

The Bronsted-Lowry theory can be used to account for the acidic and basic properties of a much wider array of substances whose properties cannot be easily explained using earlier theories.

Complete the following table by stating the pH, and give a supporting balanced chemical equation to explain the pH for each of the substances listed.

(6 marks)

Substance	pH (acidic, basic or neutral)	Equation
$Mg(CH_3COO)_2$ (aq)	**Basic (1)**	**$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-$ (1)**
NH_4Cl (aq)	**Acidic (1)**	**$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$ (1)**
$NaHSO_4$ (aq)	**Acidic (1)**	**$HSO_4^- + H_2O \rightleftharpoons SO_4^{2-} + H_3O^+$ (1)**

Question 29 **(4 Marks)**

The following chemical equation represents an unbalanced redox reaction.

$$MnO_4^- (aq) + C_2O_4^{2-} (aq) \longrightarrow Mn^{2+} (aq) + CO_2 (g)$$

In the appropriate spaces below, write the two separate half-equations, and the overall balanced redox equation.

(4 marks)

Oxidation: $(C_2O_4^{2-} \longrightarrow 2\,CO_2 + 2e^-)$ **x 5** **(1)**

Or $H_2C_2O_4 \longrightarrow 2CO_2 + 2H^+ + 2e^-$

Reduction: $(MnO_4^- + 8\,H^+ + 5\,e^- \longrightarrow Mn^{2+} + 4\,H_2O)$ **x 2** **(1)**

Overall Redox:

$5\,C_2O_4^{2-} + 2\,MnO_4^- + 16\,H^+ \longrightarrow 10\,CO_2 + 2\,Mn^{2+} + 8\,H_2O$ **(2)**

Or $5\,H_2C_2O_4 + 2\,MnO_4^- + 6\,H^+ \longrightarrow 10\,CO_2 + 2\,Mn^{2+} + 8\,H_2O$

Question 30 **(6 Marks)**

Bromine water, which is a dilute aqueous solution of bromine in water, is slightly acidic because of its reaction with water, represented by the following equation:

$$Br_2(aq) + H_2O(l) \rightleftharpoons HBrO(aq) + H^+(aq) + Br^-(aq)$$

In aqueous solution, bromine, $Br_2(aq)$ is brown. Hypobromous acid, HBrO (aq), and bromide ions, $Br^-(aq)$ are both colourless.

State and explain the colour changes that would be observed, if the following changes are made to the system at equilibrium.

(a) Addition of NaOH (aq).

(3 marks)

Colour: **Brown colour fades, or solution turns less brown. (1)**

Explanation:

Addition of OH^- causes a decrease in the $[H^+]$ as the combination of the two ions produce water (H_2O). (1)

This will result in the rate of collision of reactants being greater than that of products, shifting the equilibrium to the right, favouring the forward reaction rate. Thus the $[Br_2]$ decreases causing the brown colour to fade. (1)

(b) Addition of excess HCl (aq). (3 marks)

Colour: **Brown colour becomes more intense, or solution becomes more brown. (1)**

Explanation:

Addition of HCl causes an increase in the $[H^+]$ on product side, leading to a higher rate of collision of products than the reactants. (1)

This will shift the equilibrium to the left, favouring the reverse reaction, leading to an increase in the [Br_2], and the solution becomes more brown. (1)

Question 31 **(5 marks)**

Sulphuric acid can be manufactured by the following series of reactions

$4\ FeS_2\ (s) + 11\ O_2\ (g) \rightarrow 2\ Fe_2O_3\ (s) + 8\ SO_2\ (g)$

$2\ SO_2\ (g) + O_2\ (g) \rightleftarrows 2\ SO_3\ (g) + \text{Heat}$

$SO_3\ (g) + H_2O\ (l) \rightarrow H_2SO_4\ (aq)$

Calculate the mass of sulphuric acid which can be produced from 2.00×10^2 Kg of iron pyrites (FeS_2)

$4\ FeS_2\ (s) + 15\ O_2\ (g) + 8\ H_2O\ (l) \rightarrow 2\ Fe_2O_3\ (s) + 8\ H_2SO_4\ (aq)$ (1)

OR $1\text{mol}\ FeS_2\ (s) \rightarrow 2\ H_2SO_4\ (aq)$

$n\ (FeS_2) = m / M$ (1)

$n\ (FeS_2) = 2.00 \times 10^5 / 119.8 = 1{,}669.449$ moles (1)

$n\ (H_2SO_4) = 2n\ (FeS_2) = 2 \times 1669.449 = 3{,}338.898$ moles (1)

$m\ (H_2SO_4) = n \times M = 3338.898 \times 98.016 = 327{,}265.44$ g = <u>327 Kg</u> (1)

Question 32 **(9 Marks)**

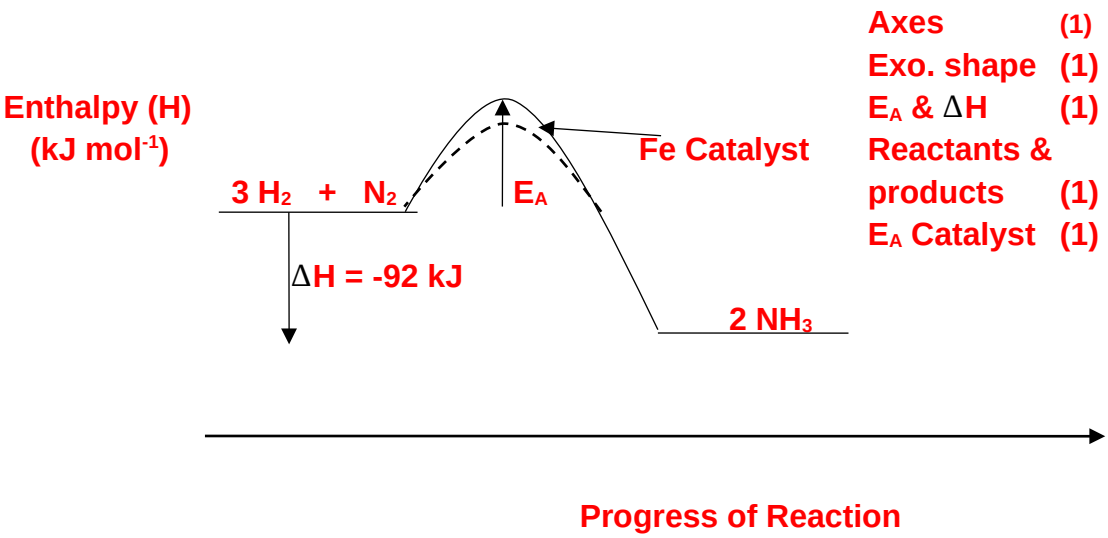
The manufacture of ammonia on an industrial scale is carried out using the Haber process, which relies on the reversible reaction of nitrogen and hydrogen in the presence of an iron catalyst, as shown in the following equation:

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

The conditions for the reaction in industry must be chosen carefully, taking into consideration not only the yield, but also the rate of the reaction. Commonly, a temperature of around 500˚C is used, and the reaction operated at a pressure of around 20,000 kPa. Since ammonia has a much higher boiling point than the other gases, it can easily be removed from the equilibrium mixture by condensation.

(a) In the space provided below, draw a fully labelled enthalpy level diagram for the Haber process, showing **ΔH**, **E_A**, **catalysed** and **uncatalysed** reaction pathways, and labelled axes.

(5 marks)



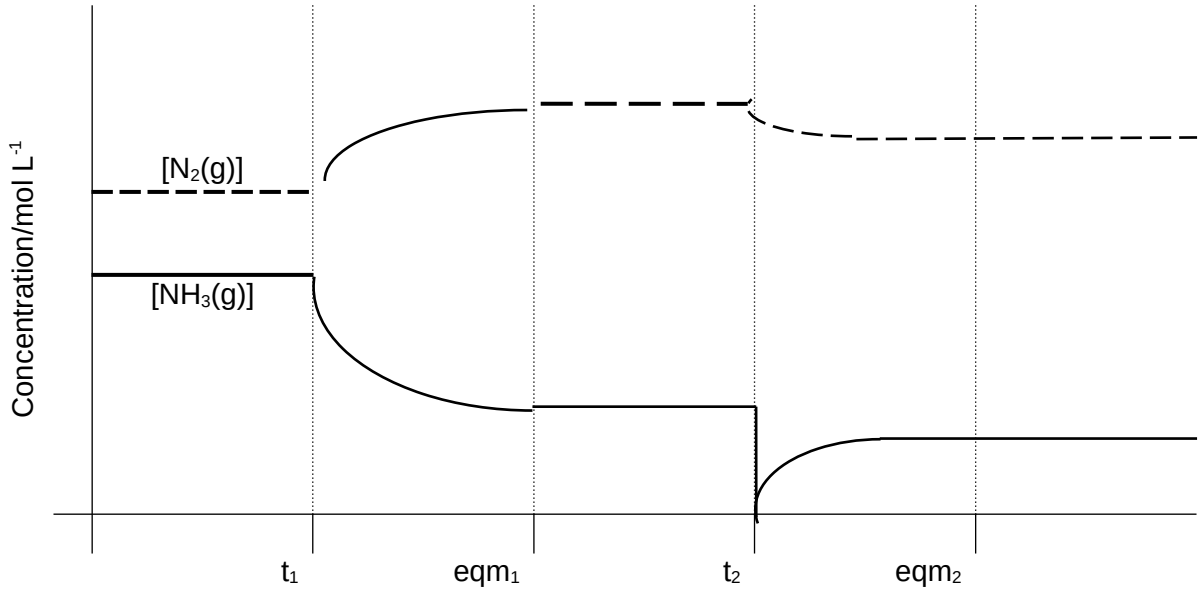
Axes	(1)
Exo. shape	(1)
E_A & ΔH	(1)
Reactants & products	(1)
E_A Catalyst	(1)

A sealed vessel containing an equilibrium mixture of nitrogen, hydrogen and ammonia was subjected to the following changes in conditions:

- At a time, t_1, the temperature of the vessel was increased
- At a time, eqm_1, the system had returned to equilibrium
- At a time, t_2, all ammonia was removed from the system
- At a time, eqm_2, the system had again returned to equilibrium

(b) Complete the following graph, to show what happens to the concentrations of nitrogen and ammonia as the above changes are made.

(5 marks)



Award (2) marks for showing the correct shape and orientation for the N_2
(2) marks for the correct shape and orientation for the NH_3 lines
(1) mark for correct ratio N_2 and NH_3
[minus marks if 1) at t_2 NH_3 is not zero and 2) conc changes to greater or lesser amount after equilibrium]

Question 33 **(10 Marks)**

Aluminium salts are acidic due to the presence of the hexaaqualuminate ion, $[Al(H_2O)_6]^{3+}$ which is formed when a soluble aluminium salt is dissolved in water. This ion undergoes hydrolysis as follows:

$$[Al(H_2O)_6]^{3+}(aq) + H_2O(l) \rightleftharpoons [Al(OH)(H_2O)_5]^{2+}(aq) + H_3O^+(aq)$$

(a) Write the equilibrium constant (K) expression for this reaction. (1 mark)

$$K = \frac{[(Al(OH)(H_2O)_5)^{2+}]\,[H_3O^+]}{[(Al(H_2O)_6)^{3+}]} \quad \textbf{(1)}$$

(b) A solution of aluminium nitrate has a pH of 5.6.

(i) Using the above equilibrium reaction, explain how the pH of the solution would change, if more crystals of hydrated aluminium nitrate were dissolved into the solution. (3 marks)

The addition of a soluble Al – salt will lead to an increase in $[(Al(H_2O)_6)^{3+}]$. (1)

Thus leads to an increase in the forward reaction rate and the reversed rate is initially unchanged therefore a shift in equilibrium to the right (1)

Consequently leading to a higher $[H_3O^+]$ and a lowering in the pH. (1)

(ii) When a small volume of dilute sodium hydroxide was added to a sample of the original solution, the pH initially increased from 5.6 to 6.0, and then decreased back to 5.8. Explain these observations.

(3 marks)

Initially the addition of excess OH^- will cause an increase in pH to 6.0. (1)

As the neutralisation of OH^- and H^+ takes place, the rate of collision of reactants will be higher than that of the products, thus the rate of the F'wd reaction is favoured. (1)

This will lead to an increase in $[H_3O^+]$ and thus decrease the pH to 5.8. (1)

(c) It was found that when the aluminium nitrate solution was warmed, the pH of the solution decreased. From this information, deduce whether the forward reaction in the above equilibrium is endothermic or exothermic. Explain your reasoning.

(3 marks)

As the pH has decreased due to an increase in the $[H^+]$, caused by an increase in temp; (1)

clearly the F'wd reaction has been favoured by this imposed change, (ie. higher temp). (1)

In order for the reaction to respond in this way, (ie. shifting the equilibrium to the right), the F'wd reaction must be ENDOTHERMIC. (1)

Question 34 **(8 Marks)**

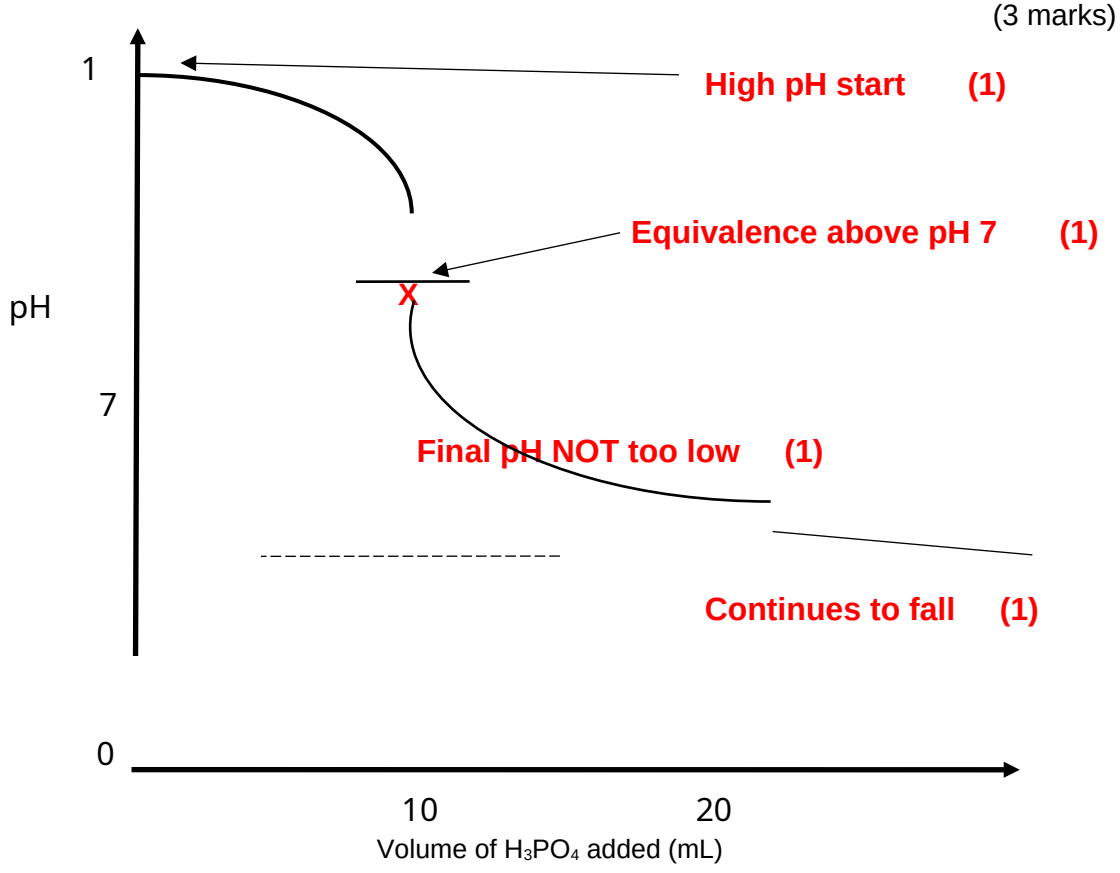
Phosphoric acid is a weak, tri**protic** acid. In an experiment, a solution of approximately 0.2 mol L^{-1} phosphoric acid (H_3PO_4) is titrated with a standard solution of 0.200 mol L^{-1} sodium hydroxide in order to determine the accurate concentration of the acid. 30.00 mL of the sodium hydroxide solution was pipetted into a conical flask, and the phosphoric acid added from the burette.

(a) Write a balanced molecular equation, including state symbols, for the reaction occurring. (2 marks)

H_3PO_4 (aq) + 3NaOH (aq) → Na_3PO_4 (aq) + $3H_2O$ (l) (2)

Deduct 1 x mark if missing or incorrect state symbols.

(b) On the axis below, sketch a graph showing how the pH would be expected to change during the titration, until an excess of the acid was added. (3 marks)



(c) On the graph above, label the equivalence point for this reaction. (1 mark)

(d) What should the pipette be rinsed with, immediately prior to use? (1 mark)

The NaOH solution. (1)

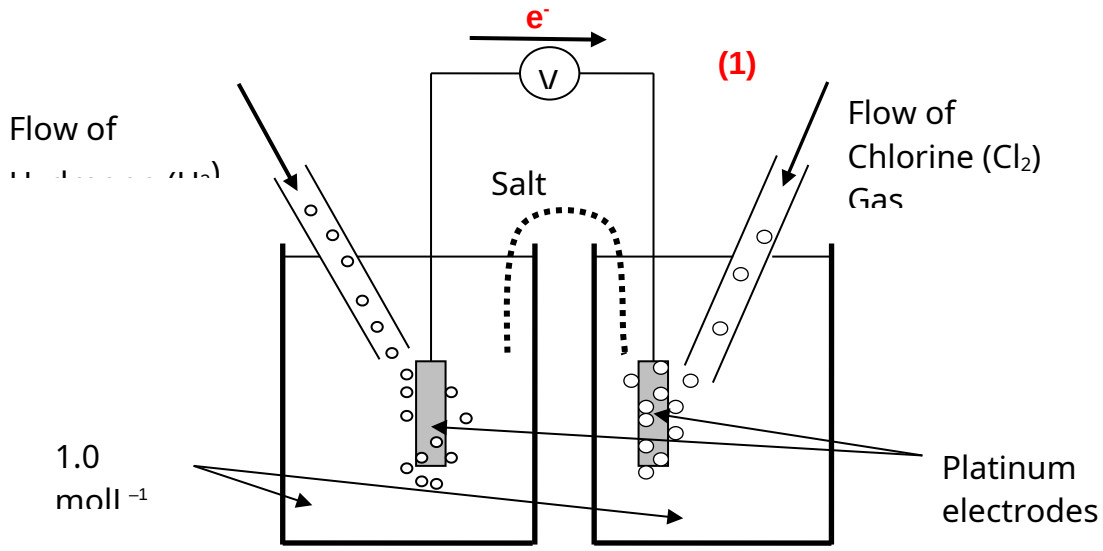
(e) From the list below, circle the correct indicator, that would be suitable for use in this particular titration. (1 mark)

(1)

Methyl orange (pH 3.1 – 4.4) | **Phenolphthalein** (pH 8.3 – 10.0) | **Bromothymol blue** (pH 6.0 – 7.6)

Question 35 **(6 Marks)**

Below is a representation of an electrochemical cell, which involves the reaction of hydrogen and chlorine:



(a) Give the half equation for the reactions occurring at the anode and at the cathode and then write an overall balanced redox equation for the reaction occurring in the cell.

(3 marks)

Cathode half-equation: $Cl_2 + 2e^- \rightarrow 2Cl^-$ (1)
Anode half-equation: $H_2 \rightarrow 2H^+ + 2e^-$ (1)
Overall equation: $Cl_2 + H_2 \rightarrow 2Cl^- + 2H^+$ (1)

(b) Using the standard reduction potential values from the data sheet, calculate the maximum theoretical voltage (e.m.f.) that could be produced by this cell.

(1 mark)

E.m.f. = (+1.36) + (0.00) = + 1.36 V (1)

(c) Show the direction of the flow of electrons in the external circuit by means of an **arrow** "(⟶)" in the diagram above.

***See on Diagram above.** (1 mark)

(d) Suggest a reason why platinum, (Pt), is used for the electrodes. (1 mark)

Platinum is INERT so it will not take part in the reaction. (1)
***Can also accept, "will allow for electron transfer".**

Question 36 **(6 Marks)**

Use the Standard Reduction Potentials from your Data Booklet to answer the following questions. In each case, write all relevant half-equations with their respective E^o values. (If the reaction is likely to occur, write an overall balanced redox equation with the resultant cell voltage). Then you must state clearly if the reaction is likely or unlikely to occur as described.

(a) A piece of aluminium metal is placed in a 1.00 mol L^{-1} nickel nitrate solution.
(3 marks)

$2 \times (Al \longrightarrow Al^{3+} + 3e^-)$ $E^o = +1.68$ V

$3 \times (Ni^{2+} + 2e^- \longrightarrow Ni)$ $E^o = -0.24$ V

(1) need both

$2\,Al + 3\,Ni^{2+} \longrightarrow 2\,Al^{3+} + 3\,Ni$ EMF = + 1.44V (1)

Positive EMF, thus reaction WILL occur. (1)

(b) Silver metal is added to a 1.00 molL^{-1} sulfuric acid solution.
(3 marks)

$2 (Ag \longrightarrow Ag^+ + e^-)$ $E^o = -0.80$ V

$2\,H^+ + 2e^- \longrightarrow H_2$ $E^o = 0.00$ V

(1) need both

$2\,Ag + 2\,H^+ \longrightarrow 2\,Ag^+ + H_2$ EMF = - 0.80 V (1)

Negative EMF, thus reaction will NOT occur. (1)

***Note: Overall redox equation NOT necessary, as reaction will not occur.**

End of Section Two

Turn to next page

Section Three: Extended answer **40% (80 marks)**

This section contains **five (5)** questions. You must answer **all** questions. Write your answers in the spaces provided below.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 70 minutes.

Question 37 **(16 marks)**

Rising carbon dioxide levels in the atmosphere are believed to play an important role in the life of organisms known as calcifiers, a group that includes many forms of coral and crustaceans. These organisms use a precipitation reaction between calcium ions and carbonate ions present in sea-water to form shells and skeletons.

(a) When potassium carbonate solution is added to a solution of calcium nitrate, a precipitate of calcium carbonate is formed. 25.0 mL of 0.410 $molL^{-1}$ potassium carbonate is added to 15.0mL of 1.05$molL^{-1}$ calcium nitrate solution. Calculate the mass of the calcium carbonate precipitated. (3 marks)

$n(K_2CO_3)$ = CV ; 0.250 x 0.410 = 0.01025 moles
$n(Ca(NO_3)_2$ = CV ; 0.0150 x 1.05 = 0.01575 moles → **(1) need both**

SR = $n(K_2CO_3)$/ $n(Ca(NO_3)_2$ = 1 / 1 or $n(Ca(NO_3)_2$ / $n(K_2CO_3)$ = 1 / 1

AR = $n(K_2CO_3)$/ $n(Ca(NO_3)_2$ = 0.6507 / 1 or $n(Ca(NO_3)_2$ / $n(K_2CO_3)$ = 1.5 / 1

K_2CO_3 is the Limiting Reagent **(1)**

$n(CaCO_3) = n(K_2CO_3) = 0.01025$ moles

$m(CaCO_3) = nxM = 0.01025 \times 100.09 = 1.02592g = 1.03g$ **(1)**

A student wished to investigate the composition of prawn shells. In order to do this, the student carried out a series of reactions to convert all the carbonate in the shells, (present as $CaCO_3$), to a soluble form, (i.e. CO_3^{2-}).
The steps that the student carried out were as follows:

- The shells of 10 prawns were ground to a fine powder using a mortar and pestle.
- 2.17 g of the powder was placed in a beaker, where it was chemically treated to convert all the carbonate into a soluble form.
- The resulting mixture was then filtered to remove any insoluble substances and the filtrate transferred to a 250 mL volumetric flask and made up to the mark with distilled water.
- 20 mL aliquots of the solution in the volumetric flask were titrated against a standard solution of nitric acid with a concentration of 0.0502 mol L^{-1}.
- All burette readings were taken from the **top of the meniscus**.
- The average titre of nitric acid used was 35.05 mL.

(b) Write a balanced ionic equation for the titration reaction. (2 marks)

$CO_3^{2-}(aq) + 2\,H^+(aq) \longrightarrow H_2O(l) + CO_2(g)$ **(2)**
only one mark if molecular equation

(c) Calculate the number of moles of nitric acid titrated from the burette. (1 mark)

$n(HNO_3) = cV = 0.0502 \times 0.03505 = 0.00176$ mol (3SF) (1)

(d) Calculate the number of moles of carbonate in the 20.0 mL aliquots. (2 marks)

$n(CO_3^{2-})_{\text{in 20 mL}} = \frac{1}{2}\, n(HNO_3)$ **(1)**

$= 0.000880$ mol (3SF) **(1)**

(e) Calculate the number of moles of carbonate in the original 2.17 g of powdered prawn shells, and thus calculate the percentage by mass of calcium carbonate in the sample of prawn shells. (5 marks)

$n(CO_3^{2-})_{\text{in 250 mL}}$ = 250 / 20 x 0.000879755 = 0.010997 mol (2)

$n(CaCO_3) = n(CO_3^{2-})$ = 0.010997 mol (1)

$m(CaCO_3) = nM$ = 0.010997 x 100.09 = 1.10 g (1)

$\%(CaCO_3)_{\text{in shells}}$ = (1.10 / 2.17) x 100 = 50.7% (3SF) (1)

(f) State and explain what effect the student's decision to read the burette from the top of the meniscus would have had on the calculated percentage by mass. (3 marks)

Effect on calculated percentage (circle one) Artificially high (No effect) Artificially low

(1)

Explanation:

As the readings were taken consistently from the top of the meniscus, and since the titre value is the difference between two readings, the systematic error would have cancelled out. (1)

Thus the calculated percentage would not have been affected. (1)

Question 38 **(14 marks)**

The electroplating of various metals plays an extremely important role in industry. These reactions can be carried out on a small scale in the laboratory using standard laboratory equipment.
A typical spoon can be chrome electroplated utilising a chromium electrode and an acidified aqueous chromium nitrate solution. Using a labelled diagram, explain the process involved in electroplating the spoon.

Your answer should pay particular attention to the following areas:

(a) How the cell can be constructed. (A diagram with clear labels for the anode, cathode, electrolyte, direction of flow of electrons and ions). (6 marks)

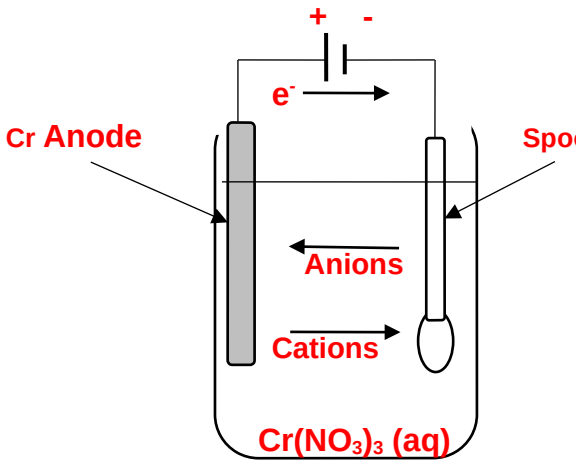
(b) Describe the processes occurring at each electrode. (Including half-equations). (4 marks)

(c) Observations made at each electrode. (2 marks)

(d) The role of the electrolyte. (1 mark)

(e) An example for the industrial importance or application of the process. (1 marks)

(a)



Correct polarity(1)
Correct electrodes(2)
Electron direction(1)
Ions direction (1)
Electrolyte (1)

(b) **At the cathode, the negative terminal of the cell provides electron for the reduction of chromium ions to chromium metal being deposited on the spoon. (1)**

Cr^{3+} (aq) + 3 e^- → Cr (s) (1)

At the anode, the positive terminal of the cell ensures the oxidation of the chromium electrode to produce chromium ions in solution. (1)

$Cr\ (s) \longrightarrow Cr^{3+}\ (aq) + 3\ e^-$ (1)

(c) At the cathode, the mass of the spoon will increase. (1)

At the anode, the mass of the electrode will decrease. (1)

(d) The electrolyte allows the transfer of ions; ie. (Cr^{3+}) cations towards the cathode and (NO_3^-) nitrate ions towards the anode, in order to balance the charges during the normal operation of the cell. (1)

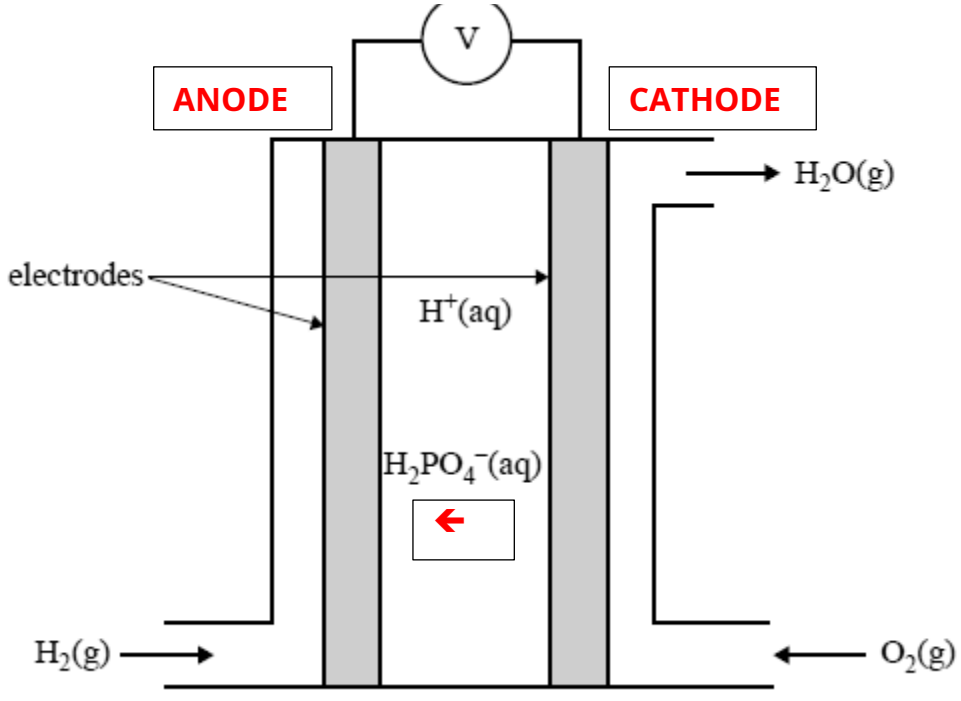
(e) Industrial importance of electrolysis includes the coating of a cheap metal with a more noble metal, ie. Jewellery, etc.

Or for the coating of iron and other reactive metals with a corrosion resistant metal such as chromium, etc.

***Accept any "one" realistic application! (1)**

Question 39 **(22 marks)**

A fuel cell that can provide power for buses is the phosphoric acid fuel cell, PAFC. The electrolyte is concentrated phosphoric acid and the reactants are hydrogen and oxygen gases.



(a) Give the anode, cathode half reactions and the redox reaction that takes place in this cell (3 marks)

Anode: $H_2(g) \rightarrow 2H^+(aq) + 2e^-$ (1)

Cathode: $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$ (1)

Redox: $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ (1)

(b) On the diagram of the fuel cell above, draw an arrow to show the direction in which the $H_2PO_4^-$ ion moves as the cell delivers an electrical current titration.

See diagram (1 mark)

(c) On the diagram of the fuel cell above, label the anode and cathode

See diagram (1 mark)

(d) Explain the difference between Primary, Secondary and Fuel cells using an example of each cell. (3 marks)

Cell	Example- **one only**	Difference	
Primary cell	Zinc /Carbon; Alkaline	Electrochemical cell that Cannot be recharged All chemicals within the cell.	(1)
Secondary cell	Lead Acid ; Car battery; Nickel Cadmium; Nickel Metal Hydride; Lithium	Both an electrochemical and electrolytic and can be recharged. All chemicals within the cell.	(1)
Fuel cell	PAFC; PEM; AFC; DMFC; SOFC.	Require a constant fuel input. Produce heat as well as electricity	(1)

(e) Explain three advantages and three disadvantages of Hydrogen Fuel Cells (6 marks)

Advantages	Disadvantages
1. Available and renewable – Very abundant – unlike fossil fuels there is no worry about running out of it. 2. Non Toxic – H_20 product is non- toxic and pose no risk to the climate or humans	1. Fossil fuels and other fuels needed -to produce Hydrogen. 2. Costly to produce – at the moment the energy is not efficient enough to produce hydrogen energy in a cost effective way 3. Flammable – hazard material , very prone to

3. Very powerful – the fuel energy of fuel cells is extremely high 4. Doesn't contribute to Climate Change – No greenhouse gas emissions 5. Cheap Maintenance – initial cost is high but once installed, very affordable to maintain.	catch fire or explode. Storage issue 4. Use of fuel cells are new – fuelling stations are not available everywhere 5. Cells at present do not hold much. –actual cells that the hydrogen energy is stored in can store only a limited amount of power.
Any three Advantages (3)	Any three Disadvantages (3)

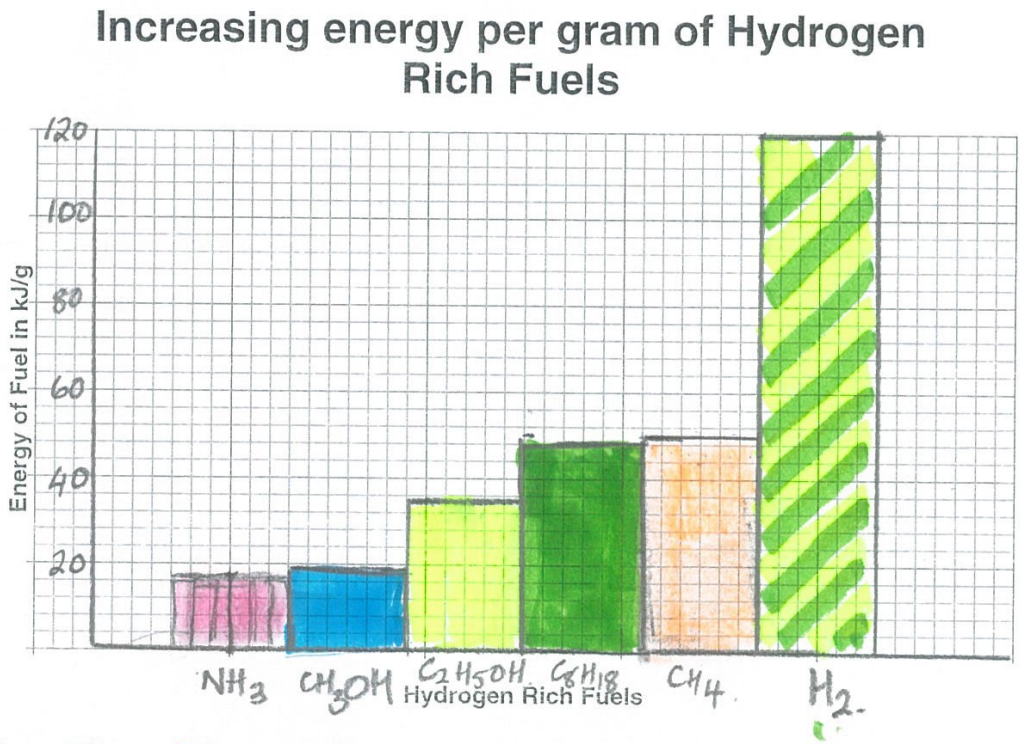
(f) Hydrogen is the most abundant element in the universe but it does not appear naturally in useful form, therefore there is research being conducted to develop economical methods of producing hydrogen. The following table describes the common and useful properties of hydrogen rich fuels.

	H_2	CH_4	NH_3	CH_3OH	C_2H_5OH	C_8H_{18}
Density (kg/l)	77	425	674	702	789	702
Freezing Point (^{0}C)	-259.2	-182.5	-77.7	-97.8	-117.3	-56.8
Boiling Point (^{0}C)	-252.7	-161.5	-33.4	64.7	78.5	125.7
Energy (kJ/mol)	241.8	802.5	316.3	638.5	1275.9	5512.0
Energy (kJ/gram)	119.9	50.0	18.6	19.9	27.7	48.3

Minus one mark for each incorrect number

Complete the table by calculating the energy of each fuel in kilojoules per gram of fuel (3 marks)

then graph this information in order of the increasing energy per gram of Fuel. (5 Marks)



Accept Bar or Column graph

Title (1);
Labelled Axis (1) ;
Scale (1);
Increasing order (1) ;
Correct polling of data(1)

Question 40 **(14 marks)**

When soils containing iron pyrite (FeS_2) are exposed to air, the following reaction can occur.

$$2\ FeS_2(s) + 7\ O_2(g) + 2\ H_2O(l) \rightarrow 2\ Fe^{2+}(aq) + 4\ SO_4^{2-}(aq) + 4\ H^+(aq)$$

These types of soils are called acid sulfate soils. The pH of groundwater in these soils will decrease. If this groundwater discharges into lakes and rivers it will also cause their pH to decrease.

(a) Explain how this reaction causes the pH of groundwater to decrease. (2 marks)

As the reaction proceeds, H^+ are produced, thus increasing $[H^+]$, (1)
and DECREASING pH. (1)

A titration was carried out on a sample of lake water, suspected of being contaminated with acid soils, to determine its pH.

A student placed a standardised solution of 0.005 $molL^{-1}$ NaOH in the burette.
The student then titrated the NaOH solution against 50.0 mL samples of the lake water and obtained the following results.

	Trial 1	Trial 2	Trial 3	Trial 4
Final burette reading (mL)	4.25	8.05	12.00	16.05
Initial burette reading (mL)	0.00	4.10	8.10	12.05
Volume of NaOH used (mL)	**4.25**	**3.95**	**3.90**	**4.00**

Calculated titres in Table (1)

(b) Determine the average volume of NaOH used. (2 marks)

Av Titre = $\frac{3.95 + 3.90 + 4.00}{3}$ = 3.95 mL (1)

(c) Calculate the average number of moles of NaOH used to neutralise the acid. (1 mark)

n = cV = 0.0050 x 0.00395 = 1.975×10^{-5} mol (3 x SF) (1)

(d) Assuming that the lake water is the only source of H^+ ions and that complete ionisation of the acid in the lake water has occurred, determine the pH of the lake water. (3 marks)

$n(H^+) = n(NaOH) = 1.975 \times 10^{-5}$ mol (1)

$[H^+] = n/V = 1.975 \times 10^{-5} / 0.050 = 3.95 \times 10^{-4}$ molL^{-1} (1)

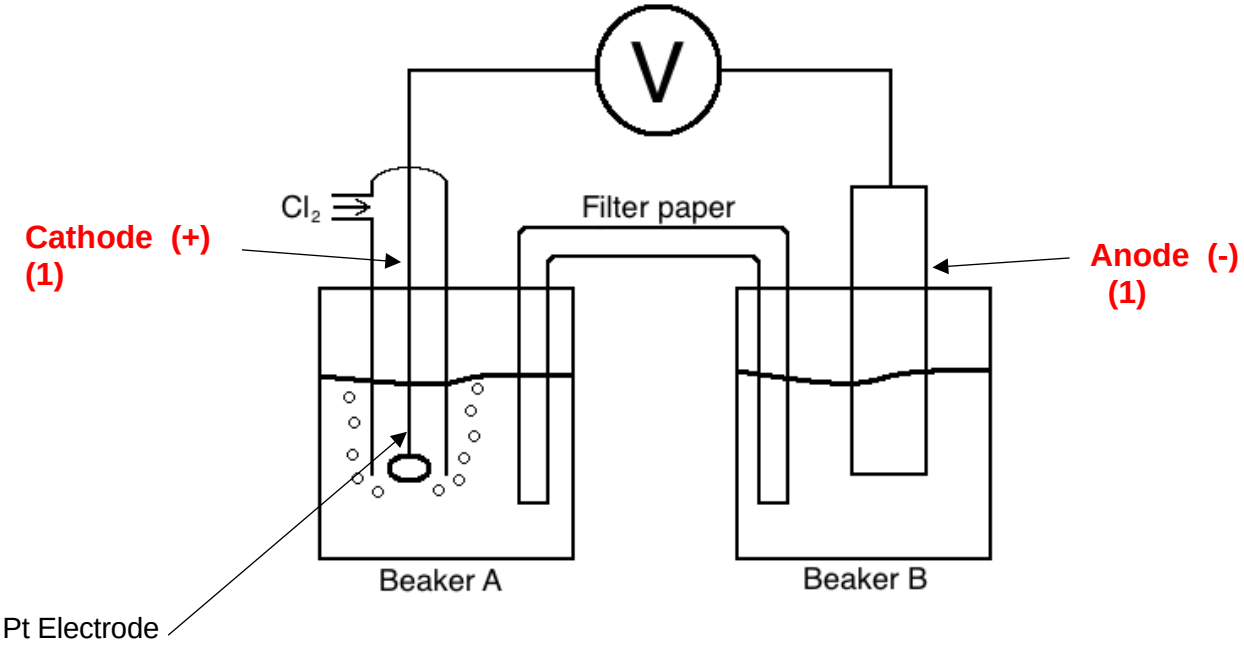
$pH = -\log[H^+] = -\log (3.95 \times 10^{-4}) = 3.40$ (3 x SF) (1)

(e) Complete the following table (6 marks)

Equipment	What is it used for in this experiment?	What should it be rinsed with before use?
Burette	**To deliver accurate volume of NaOH. (1)**	**The NaOH solution. (1)**
Pipette	**To measure 50.0 mL of lake water. (1)**	**The lake water. (1)**
Conical flask	**Where the titration reaction takes place. (1)**	**Distilled water. (1)**

Question 41 **(14 marks)**

The cell, Cu(s) / Cu^{2+}(aq) and $C\ell_2$(g) / $C\ell^-$(aq) with a platinum electrode, was set up as shown in the diagram below. **Beaker A** contained a 1.00 mol L^{-1} aqueous solution of ammonium chloride, and the filter paper shown in the diagram was soaked in an aqueous solution of potassium nitrate before being placed in the two beakers.



(a) Give the name or formula of a suitable electrolyte for use in **Beaker B**. (1 mark)

Suitable electrolyte = Copper (II) nitrate or $Cu(NO_3)_2$ solution (1)

(b) Label the **anode** and **cathode** in the diagram above, including their respective **polarities**.

See diagram (2 marks)

(c) Give **two** reasons why potassium nitrate was a suitable material for soaking the filter paper. (2 marks)

(i) KNO_3 is a "strong electrolyte", thus a high concentration of ions available for transfer between cells to balance the charge. (1)

(ii) Neither ion, (K^+) nor (NO_3^-), will form a precipitate with other ions. (1)

(d) Calculate the maximum theoretical EMF you could measure for the cell. (2 marks)

EMF = (+1.36) + (-0.34) = + 1.02 V (2)

(e) Give **one** reason why the measured cell potential might differ from the value calculated in part (d) above. (1 mark)

Concentrations may not be 1.0 mol L^{-1}, or Cl_2 (g) may not be at STP, or reaction not carried out at 25^0 C. *Accept any one reason. (1)

(f) Describe the changes that would be observed in **Beaker B** during the operation of the cell? (2 marks)

Blue colour of solution would intensify. (1)

Mass of salmon pink electrode would decrease. (1)
Do NOT accept "dissolve".

(g) Using relevant chemical theory and a chemical equation, state and explain how the voltmeter reading would change if a few drops of silver nitrate solution were placed in **Beaker A**. (4 marks)

The introduction of Ag^+ ions in Beaker A would cause the following reaction to occur:

Ag^+ (aq) + Cl^- (aq) $\rightarrow$ AgCl (s) (1)

The silver ions (Ag^+) would remove chloride ions from solution, thus favouring the forward reaction and more chlorine (Cl_2) to dissolve in order to re-establish equilibrium. (1)

This would cause an INCREASE in the voltmeter reading, (cell EMF), (1)

as more electrons would be required for the reduction of chlorine. (1)

***Can also accept other valid explanations; (i.e. more electrons would be required for f'wd or reduction reaction).**

End of questions