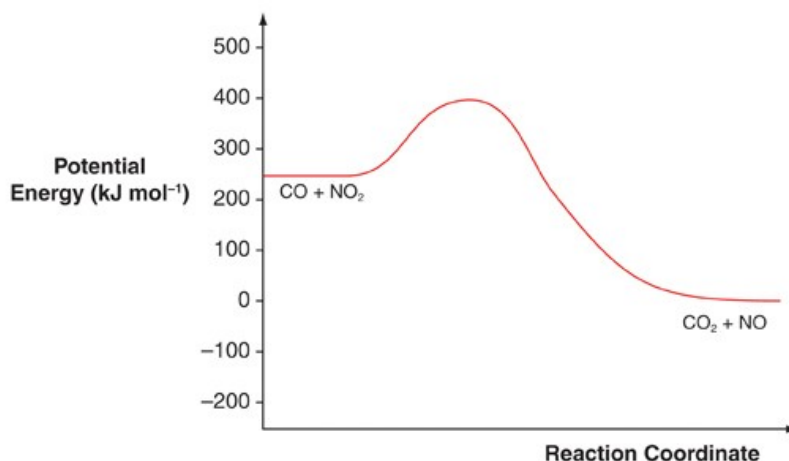


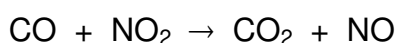
PART 1 (60 marks = 30% of paper)

Answer ALL questions in Part 1 on the separate Multiple Choice Answer Sheet provided. Each question in this part is worth 2 marks.

1. Consider the following diagram:



The activation energy (E_a) and change in enthalpy (ΔH) for the reaction:



are, respectively:

- a) 400 kJ mol⁻¹ and +250 kJ mol⁻¹
 - b) 400 kJ mol⁻¹ and 0 kJ mol⁻¹
 - c) 150 kJ mol⁻¹ and +250 kJ mol⁻¹
 - d) 150 kJ mol⁻¹ and -250 kJ mol⁻¹
2. Measured at constant temperature, the rate of reaction between magnesium and hydrochloric acid decreases as the reaction proceeds because:
- a) the reactant concentration decrease with time.
 - b) the forward and reverse reaction rates must approach zero as equilibrium is approached.
 - c) the proportion of reactant particles with energies in excess of the activation energy decreases as the reaction proceeds.
 - d) absorption of heat by the reaction diminishes the reaction rate.

3. In which one of the following would the position of the equilibrium not be affected by a volume change at constant temperature?

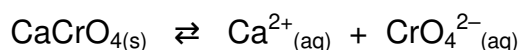
- a) $2 \text{CO}_{(\text{g})} + \text{O}_{2(\text{g})} \rightleftharpoons 2 \text{CO}_{2(\text{g})}$
- b) $\text{C}_2\text{H}_{6(\text{g})} \rightleftharpoons \text{C}_2\text{H}_{4(\text{g})} + \text{H}_{2(\text{g})}$
- c) $\text{N}_2\text{O}_{4(\text{g})} \rightleftharpoons 2 \text{NO}_{2(\text{g})}$
- d) $\text{CO}_{(\text{g})} + \text{H}_2\text{O}_{(\text{g})} \rightleftharpoons \text{H}_{2(\text{g})} + \text{CO}_{2(\text{g})}$

4. Methanol is made by the reaction of carbon monoxide and hydrogen.



The reaction is slow at room temperature and pressure. An increase in both the yield at equilibrium and the rate of reaction could be achieved by:

- a) increasing the temperature to 80°C.
 - b) adding a catalyst.
 - c) cooling the system.
 - d) increasing the pressure at constant temperature.
5. The solubility of calcium chromate is 0.900 mol L^{-1} at 25°C. Consider the equilibrium:



An equilibrium mixture is prepared by adding a few yellow crystals of calcium chromate to water, which produces a yellow solution. Some of the yellow crystals remain undissolved.

What is observed when a little concentrated calcium chloride solution is added to the mixture?

- a) More yellow crystals form and the solution becomes paler.
- b) More yellow crystals form and the solution becomes a darker yellow.
- c) The yellow crystals dissolve and the solution becomes paler.
- d) The yellow crystals dissolve and the solution becomes darker yellow.

6. Consider a sealed system in which KClO_3 , KCl and O_2 are at equilibrium, according to the following equation:



Now consider the following actions:

- I Add more $\text{O}_{2(g)}$ to the system
- II Add more $\text{KClO}_{3(s)}$ to the system
- III Decrease the volume of the system
- IV Increase the temperature of the system

Which statement below is true?

- a) All actions lead to a change in $\text{O}_{2(g)}$ concentration.
 - b) Only II, III and IV lead to a change in $\text{O}_{2(g)}$ concentration.
 - c) Only III and IV lead to a change in $\text{O}_{2(g)}$ concentration.
 - d) Only IV leads to a change in $\text{O}_{2(g)}$ concentration.
7. The first five ionisation energy values (in MJ mol^{-1}) for element X are:

0.6 1.4 12.1 13.4 14.1

Which of the following statements is true?

- a) The ground state electron configuration of X is $1s^2 2s^2$.
 - b) X is located in the second period of the Periodic Table.
 - c) The oxide of X will have the formula XO and it will be acidic.
 - d) The 3rd electron to be removed will be located in a different energy level than its valence electrons.
8. The number of non-bonding valence electrons pairs in N_2O_5 ($\text{O}_2\text{N}-\text{O}-\text{NO}_2$) is:
- a) 10
 - b) 12
 - c) 14
 - d) 16

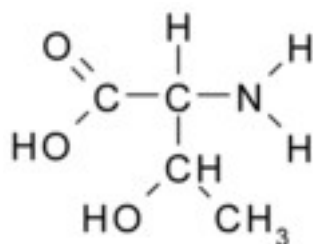
9. Consider the following molecules:

- | | |
|-----|-------------------------|
| I | C_2F_2 |
| II | CH_3F |
| III | CH_2F_2 |
| IV | CHF_3 |
| V | CF_4 |

Which would have a permanent dipole?

- a) II and IV only
 - b) II, III and IV only
 - c) I, II, III and IV only
 - d) I, II, III, IV and V
10. Boron nitride, BN, is insoluble in water, has very poor electrical conductivity in any state and melts at 2973°C . The most likely structure of solid boron nitride is:
- a) ionic.
 - b) organic.
 - c) covalent molecular.
 - d) covalent network.
11. Which of the following best explains why sodium chloride is virtually insoluble in ethanol?
- a) Sodium and chloride ions are not molecules and cannot form intermolecular forces with ethanol, therefore it does not dissolve.
 - b) Although both sodium chloride and ethanol are considered polar, they are not sufficiently similar for the "like dissolves like" rule to apply.
 - c) Sodium and chloride ions do not form sufficiently strong ion-dipole forces to disrupt the sodium chloride crystal lattice and overcome the intermolecular forces between ethanol molecules.
 - d) The dispersion forces between sodium chloride molecules and ethanol molecules are too weak to overcome the stronger hydrogen bonds between ethanol molecules.

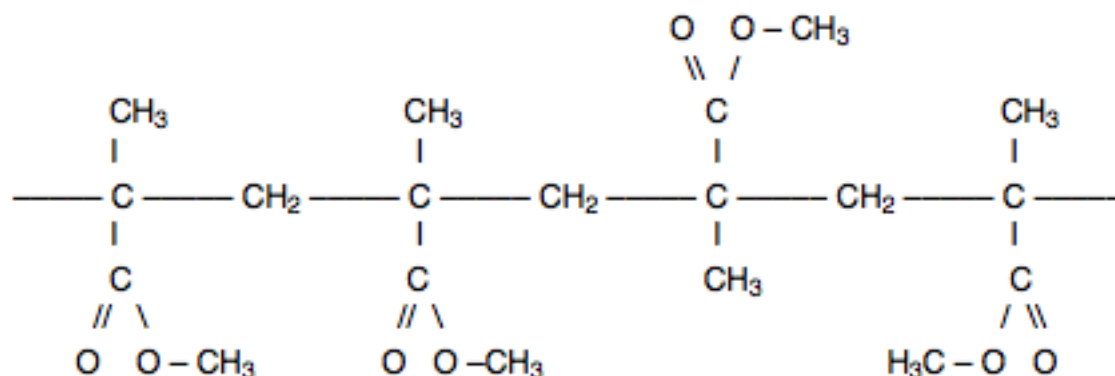
12. Which of the lists below correctly states all of the functional groups found in the compound whose structure is shown below? Consider the following molecule:



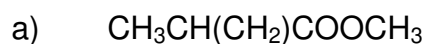
- a) carboxylic acid and amide
b) alcohol, ketone and amine
c) aldehyde, amine and alcohol
d) alcohol, carboxylic acid and amine
13. Based on your understanding of intermolecular forces, which of the following could form hydrogen bonds with water molecules?
- I CH₃CH₂COOH
II CH₃CHFCH₃
III CH₃CHO
IV (CH₃)₃COH
- a) I and II only
b) I and IV only
c) I, III and IV only
d) I, II, III and IV
14. A molecule with formula C₅H₁₂O reacts vigorously with sodium metal and with acidified sodium dichromate. Following the latter reaction a different substance was distilled from the reaction vessel which failed to react with either sodium or acidified sodium dichromate. The molecule C₅H₁₂O could contain:
- a) a primary alcohol group.
b) an aldehyde group.
c) a secondary alcohol group.
d) a tertiary alcohol group.

15. Which of the following exhibits geometric isomerism?
- a) H_2CCFBr
 - b) propene
 - c) methyl-2-butene
 - d) 1-chloro-1-butene
16. An organic compound is analysed and found to have the empirical formula $\text{C}_3\text{H}_6\text{O}$. The compound does not react with sodium or acidified potassium dichromate solution. It could be:
- a) 1-propanol
 - b) propanal
 - c) 1-butyl ethanoate
 - d) ethyl butanoic acid
17. Which of the following represents a soap?
- a) $\text{CH}_3(\text{CH}_2)_{16}\text{COOK}$
 - b) NaOH
 - c) CH_3COONa
 - d)
$$\begin{array}{c} \text{CH}_2\text{OH} \\ | \\ \text{CHOH} \\ | \\ \text{CH}_2\text{OH} \end{array}$$

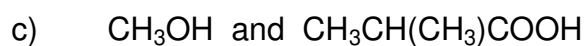
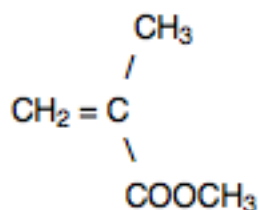
18. The polymer from which Perspex is made has the structure:



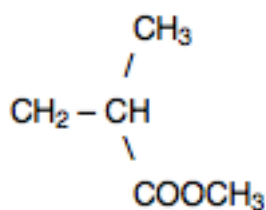
Which of the following is/are the correct structures of the monomer/s used to make Perspex?



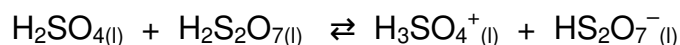
b)



d)

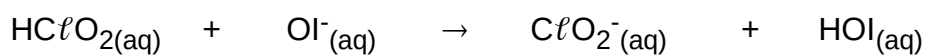
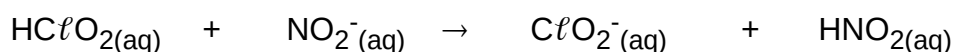
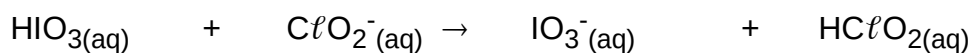
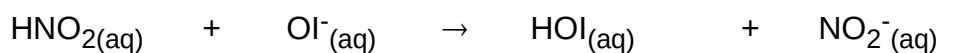


19. Sulfuric acid can react with pyrosulfuric acid according to the equation:



The species acting as acids in this reaction are:

- a) H_2SO_4 and H_3SO_4^+
 - b) H_2SO_4 and HS_2O_7^-
 - c) $\text{H}_2\text{S}_2\text{O}_7$ and HS_2O_7^-
 - d) $\text{H}_2\text{S}_2\text{O}_7$ and H_3SO_4^+
20. A series of reactions were carried out between acids and sodium salts. Each reaction proceeded almost to completion. Equations for the reactions were:



Which of the following is the strongest acid?

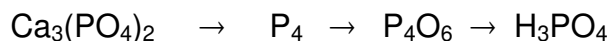
- a) $\text{HNO}_{2(aq)}$
 - b) $\text{HIO}_{3(aq)}$
 - c) $\text{HClO}_{2(aq)}$
 - d) $\text{HOI}_{(aq)}$
21. A 0.200 mol L^{-1} solution of hydrogen fluoride, HF, is found to have a pH of 3.5. The percentage ionisation of HF is:
- a) 0.158 %
 - b) 3.16 %
 - c) 3.50 %
 - d) 17.5 %

22. Which of the following reagents would be useful in distinguishing between solutions of zinc nitrate and aluminum nitrate?
- a) 0.1 mol L^{-1} magnesium sulfate solution
 - b) concentrated ammonia solution
 - c) 1 mol L^{-1} nitric acid
 - d) concentrated sodium hydroxide solution
23. Which one of the following, when dissolved in water, would result in a basic solution?
- a) NaCl
 - b) NH_4NO_3
 - c) $\text{Mg}(\text{NO}_3)_2$
 - d) K_3PO_4
24. In a titration of a strong base with a weak acid the following procedure was used:
- I A burette was rinsed with the standard base solution and then filled with the standard base solution.
 - II A pipette was rinsed with the acid solution.
 - III A conical flask was rinsed with water.
 - IV The pipette was used to transfer a measured volume of the acid solution into the conical flask.
 - V Methyl orange indicator was added to the acid sample and it was titrated to the end point with the base.
 - VI The concentration of the acid was evaluated.

Which statement is correct?

- a) The calculated acid concentration will be correct.
- b) The calculated acid concentration will be too low.
- c) The calculated acid concentration will be too high.
- d) No definite conclusion can be reached about the acid concentration.

25. The changes that occur during the manufacture of phosphoric acid from crude calcium phosphate can be described by:



The oxidation numbers of phosphorous in this sequence are, respectively:

- a) +5 -3 +4 +5
b) +5 0 +3 +5
c) -3 +4 +4 -3
d) +8 0 +3 +5
26. Which of the following could be classified as a disproportionation reaction?
- a) $\text{ZnO} + 2 \text{OH}^- + \text{H}_2\text{O} \rightarrow \text{Zn}(\text{OH})_4^{2-}$
b) $2 \text{BrO}_3^- + 10 \text{Br}^- + 12 \text{H}^+ \rightarrow 6 \text{Br}_2 + 6 \text{H}_2\text{O}$
c) $3 \text{NO}_2 + \text{H}_2\text{O} \rightarrow 2 \text{HNO}_3 + \text{NO}$
d) $5 \text{H}_2\text{O}_2 + 2 \text{MnO}_4^- + 6 \text{H}^+ \rightarrow 5 \text{O}_2 + 2 \text{Mn}^{2+} + 8 \text{H}_2\text{O}$
27. Three metals, X, Y and Z and the ions X^{2+} , Y^{2+} and Z^{2+} are found to react as follows:

Metal X reacts with $1 \text{ mol L}^{-1} \text{HCl}$, but does not react with $1 \text{ mol L}^{-1} \text{Y}(\text{NO}_3)_2$

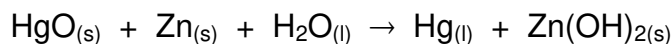
Metal Y reacts with $1 \text{ mol L}^{-1} \text{HCl}$ and also with $1 \text{ mol L}^{-1} \text{Z}(\text{NO}_3)_2$

Metal Z does not react with $1 \text{ mol L}^{-1} \text{HCl}$

Which of the following lists the ions X^{2+} , Y^{2+} , Z^{2+} and H^+ in order of increasing oxidant strength?

- a) Y^{2+} X^{2+} Z^{2+} H^+
b) Z^{2+} H^+ X^{2+} Y^{2+}
c) H^+ X^{2+} Y^{2+} Z^{2+}
d) Y^{2+} X^{2+} H^+ Z^{2+}

28. Mercury oxide-zinc batteries are used in many low power applications such as watches and calculators. The cell reaction is:



The half reaction occurring at the positive electrode of the battery is:

- a) $\text{HgO}_{(s)} + \text{H}_2\text{O}_{(l)} + 2\text{e}^- \rightarrow \text{Hg}_{(l)} + 2\text{OH}^-_{(aq)}$
 - b) $\text{Hg}_{(l)} + 2\text{OH}^-_{(aq)} \rightarrow \text{HgO}_{(s)} + \text{H}_2\text{O}_{(l)} + 2\text{e}^-$
 - c) $\text{Zn}(\text{OH})_{2(s)} + 2\text{e}^- \rightarrow \text{Zn}_{(s)} + 2\text{OH}^-_{(aq)}$
 - d) $\text{Zn}_{(s)} + 2\text{OH}^-_{(aq)} \rightarrow \text{Zn}(\text{OH})_{2(s)} + 2\text{e}^-$
29. A solution containing $1\text{ mol L}^{-1}\text{ MgSO}_4$ was electrolysed using copper electrodes.
- Which one of the following statements is correct?
- a) Hydrogen gas is produced at the cathode and copper ions are produced at the anode.
 - b) Copper is produced at the cathode and copper ions are produced at the anode.
 - c) Hydrogen gas is produced at the cathode and oxygen gas is produced at the anode.
 - d) Magnesium is produced at the cathode and copper ions are produced at the anode.
30. One way to protect iron from corrosion is to apply a coating of nickel to the metal by electrolysis. The corrosion of iron is prevented because:
- a) nickel is a stronger reducing agent than iron and is preferentially oxidised.
 - b) nickel accepts electrons from iron, preventing oxidation.
 - c) the thin coating of nickel prevents the iron from reacting with oxygen.
 - d) iron and nickel form an alloy steel which is particularly resistant to corrosion.

END OF PART 1

PART 2 (70 marks = 35% of paper)

Answer ALL questions in Part 2 in the spaces provided below.

-
1. Write equations for any reactions that occur in the following procedures. If no reaction occurs, then write 'no reaction'.

In each case describe in full what you would observe, including any: colours; odours; precipitates (give the colour); or gases evolved (give the colour or describe as colourless). If a reaction occurs but the change is not visible, then you should state this.

- a) Propane is bubbled through bromine water while exposed to sunlight.

Equation _____

Observation _____

-
- b) Solutions of barium hydroxide and propanoic acid are mixed.

Equation _____

Observation _____

-
- c) Excess ammonia solution is added to solid zinc hydroxide.

Equation _____

Observation _____

-
- d) 1.0 mol L⁻¹ sodium chloride in acid is added to 1.0 mol L⁻¹ sodium permanganate

Equation _____

Observation _____

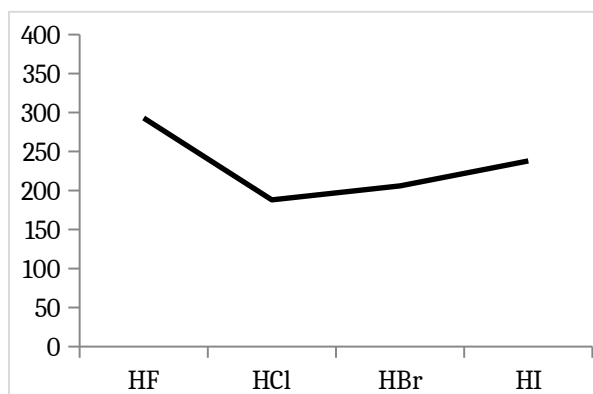
[3 x 3 = 12 marks]

2. Draw electron dot diagrams for the following, showing all valence electrons as either $\cdot\cdot$ or $-$.

a) NH_4CN	b) H_2SO_4 molecule
---------------------------	-------------------------------------

[4 marks]

3. Consider the following graph, which depicts the boiling points (in Kelvin) of the group VII hydrides.



Briefly account for the shape of the graph.

[2 marks]

4. Complete the following table using the list of substances below. Whilst there may be more than one possible answer, only one answer per box is required. You may use the same substance more than once.

HCHO H₂O₂ HCN SiO₂ SO₃ O₃ CO₂ CH₄ NCl₃

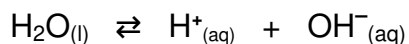
a) a polar linear molecule	
b) a substance with hydrogen bonds between its molecules	
c) a substance with only dispersion forces between its molecules	
d) a polar trigonal planar molecule	
e) a polar molecule with non-polar bonds	
f) a non-polar molecule with polar bonds	

[6 marks]

5. Ammonium acetate (ethanoate) is soluble in water. Explain, with the aid of equations, why it would be difficult to predict whether a 0.100 mol L⁻¹ solution of ammonium acetate is acidic or basic.

[4 marks]

6. Water self-ionises as follows:



The value of K_w varies with temperature as follows:

$$25^\circ\text{C} \quad K_w = 1.0 \times 10^{-14}$$

$$50^\circ\text{C} \quad K_w = 5.5 \times 10^{-14}$$

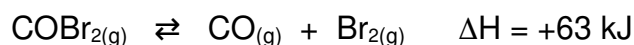
Use the above information to answer and explain the following:

- a) In the self-ionisation of water, is the forward reaction endothermic or exothermic? Explain your answer.

- b) Calculate the pH of water at 50°C .

(3,2 = 5 marks)

7. The decomposition of carbonyl bromide is given by the following equation:



- a) Write the equilibrium law expression for this reaction.

[1 mark]

- b) Complete the following table:

Change in equilibrium system	Effect on the rate of the forward reaction when equilibrium is reestablished (increase, decrease or no change)	Effect on the number of moles of COBr_2 (increase, decrease, or no change)	Effect on the equilibrium constant, K (increase, decrease, or no change)
a) carbon monoxide is added to the reaction vessel at constant volume and temperature			
b) the temperature is increased at constant volume			
c) argon is added at constant pressure and temperature			
d) ethene is introduced to the flask at constant volume and temperature			

[12 marks]

8. For the following pairs of chemicals, give a simple test and observation by which you can distinguish between them.

a) two colourless liquids: 3-methyl-2-butanol and 2-methyl-2-butanol

Test: _____

Observations:

3-methyl-2-butanol _____

2-methyl-2-butanol _____

b) two colourless liquids: hydrogen peroxide solution and water

Test: _____

Observations:

$\text{H}_2\text{O}_{2(\text{aq})}$ _____

$\text{H}_2\text{O}_{(\text{l})}$ _____

[6 marks]

9. Write the anode and cathode reactions for the following cells:

a) electrolysis of $\text{AgNO}_{3(\text{aq})}$ using a Pt anode and Ag cathode

anode _____

cathode _____

b) the H_2/O_2 fuel cell in acidic conditions

anode _____

cathode _____

c) recharging the lead-acid accumulator (car battery)

anode _____

cathode _____

[6 marks]

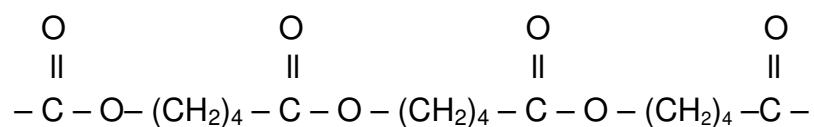
10. a) Use one or more of the following molecules to sketch a section of the appropriate polymer. Your sketch should show at least two repeating units.

- *cis*-2-butene
- $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{OH}$
- HOOCCOOH

Addition polymer

Condensation polymer

- b) Sketch the monomer/s that would be used to make the polymer whose structure is shown below.



[2,2,2 = 6 marks]

11. There are several isomers with molecular formula C_4H_8O . Draw full structural formula(e) of isomer(s) that fit the following descriptions;

Description	Structural Formula(e)
a) the product of oxidising 2-butanol using acidified sodium dichromate	
b) it can be oxidised to 2-methylpropanoic acid using acidified potassium permanganate	
c) a saturated primary alcohol	
d) a saturated secondary alcohol	
e) a pair of geometric isomers	

[6 marks]

END OF PART 2

PART 3 (50 marks = 25% of paper)

Answer ALL questions in Part 3. The calculations are to be set out in detail in this Question/Answer booklet. Marks will be allocated for correct equations and clear setting out, even if you cannot complete the problem. When questions are divided into sections, clearly distinguish each section using (a), (b), and so on. Express your final numerical answers to three (3) significant figures where appropriate, and provide units where applicable. Information that may be necessary for solving the problems is located on the separate Chemistry Data Sheet. Show clear reasoning: if you do not, you will lose marks.

1. A pure solid compound contains only the elements phosphorus, sulfur and chlorine. Analytical work on the material is reported below.

0.639 g of the compound was dissolved in 25.0 mL of distilled water when all the chlorine in the compound was converted to the chloride ion. This solution required 22.50 mL of 0.500 mol L⁻¹ silver nitrate solution to precipitate all of the chloride.

A further 0.847 g of the compound was dissolved in water. The phosphorus in the compound was completely converted to magnesium pyrophosphate, Mg₂P₂O₇, which weighed 0.562 g

- a) Calculate the empirical formula of the compound.
- b) 0.482 g of the solid compound was placed in a 300 mL vessel, which was evacuated and then heated to 250°C at which temperature the solid completely vapourised giving a pressure of 41.33 kPa. Calculate the molecular mass of the compound.
- c) What is the molecular formula of the compound?

[11 marks]

3. Three solutions – **X**, **Y** and **Z** – have the following composition:

Solution X: 50.0 ml of 0.210 mol L⁻¹ sulfuric acid was diluted with distilled water and the resulting solution made up to 250.0 mL

Solution Y: 585.0 mL of hydrogen chloride gas at 101.3 kPa and 273 K (S.T.P.) was dissolved in distilled water and the resulting solution made up to 500.0 mL

Solution Z: 100.0 mL contains 0.557 g of sodium hydroxide

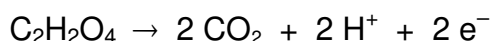
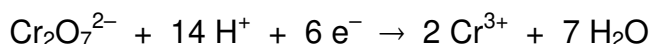
- Calculate the concentration in mol L^{-1} of each solution.
- 30.0 mL of each solution are mixed. Calculate the pH of the resultant mixture.

[13 marks]

4. a) A potassium dichromate solution is standardised using oxalic acid.

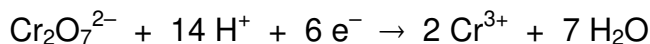
4.277 g of oxalic acid ($\text{C}_2\text{H}_2\text{O}_4$) is dissolved in water and made up to 250.0 mL in a volumetric flask. 20.0 mL of the oxalic acid solution, to which dilute sulfuric acid is added, is titrated with potassium dichromate solution. A volume of 25.55 mL of $\text{Cr}_2\text{O}_7^{2-}$ is required.

Using the half-equations given below, determine the concentration of the potassium dichromate solution.



- b) A person's blood alcohol ($\text{C}_2\text{H}_5\text{OH}$) level can be determined by titrating a sample of blood plasma with potassium dichromate solution.

The ethanol is oxidised to ethanoic acid and the dichromate is reduced to Cr^{3+} . The half equations for the oxidation of ethanol and the reduction of $\text{Cr}_2\text{O}_7^{2-}$ are:



If 35.46 mL of the potassium dichromate solution from a) is required to titrate 25.00 g of blood plasma. Determine the percentage by mass of alcohol in the blood.

[8 marks]

5. A current of 5.20 amps were passed into two cells in series containing solutions of $\text{Na}[\text{Au}(\text{CN})_2]$ (cell 1) and $\text{Hg}_2(\text{NO}_3)_2$ (cell 2) using graphite electrodes.

In cell 1, operating at 68.1% efficiency, 0.124 g of gold was produced at the cathode.

- What time did it take to deposit that mass of gold?
- What mass mercury would be produced at the cathode in cell 2 in double that time (in a) above) if cell 2 is 81.3% efficient?

[10 marks]

END OF PART 3

PART 4 (20 marks = 10% of paper)

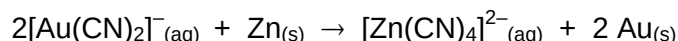
Answer the following extended answer question. Where applicable use equations, diagrams and illustrative examples of the chemistry you are describing.

Marks are awarded for the relevant chemical content of your answer, but you will lose marks if what you write is unclear or lacks coherence.

Zinc is a shiny silvery-coloured metal that melts at 420°C and boils at 907°C. There are several isotopes, the most common being ^{64}Zn . Zinc can be rolled into sheets or drawn into wires, and these properties are improved by heating the metal to over 100°C. Its electrical conductivity is about one quarter that of copper.

Zinc burns in oxygen to form zinc oxide, which is used as a white pigment in paints and has a melting point of 1975°C. Zinc, as well as its oxides and hydroxides, are classified as amphoteric. The reaction of zinc with dilute acid is often used to generate small quantities of hydrogen gas in the laboratory. Zinc carbonate decomposes to form zinc oxide and carbon dioxide when heated above 300°C and so is used in some fire proofing applications.

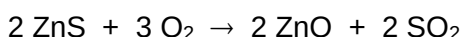
Zinc is used to galvanise iron and as a sacrificial anode for underground steel pipes and steel rudders on large ships. It is also used as the case of dry cells. Zinc has been used in the extraction of gold, in which a solution containing a complex gold ion, $[\text{Au}(\text{CN})_2]^-_{(\text{aq})}$, is passed through crates containing powdered zinc. The following reaction occurs:



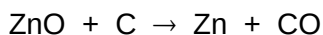
Like most metals, zinc occurs in nature combined with other elements rather than in its metallic form. A common zinc-containing mineral found in Australia is zinc sulfide (known as *sphalerite*).

Zinc can be extracted from sphalerite by the following process:

1. Rocks containing sphalerite are finely crushed.
2. The finely crushed sphalerite is heated in air:



3. The ZnO is mixed with charcoal (carbon) and heated to over 1000°C, which causes the following reaction to occur:



At these temperatures, the zinc that is formed evaporates. The vapour is collected and cooled, allowing the molten metal to be collected.

An alternative method is for the zinc oxide from step 2 to be reacted with sulfuric acid forming a zinc sulfate solution. The zinc is then recovered from the solution via electrolysis using aluminum electrodes (note: at the non-standard conditions of the cell, the reduction of zinc is more likely than the reduction of water). In ores that contain cadmium, the cadmium ions are removed from solution prior to electrolysis by the addition of powdered zinc.

Drawing on your understanding of the chemistry that you have studied this year, discuss the properties and uses of zinc and its compounds as well as the extraction of zinc from its ore.

END OF EXAMINATION