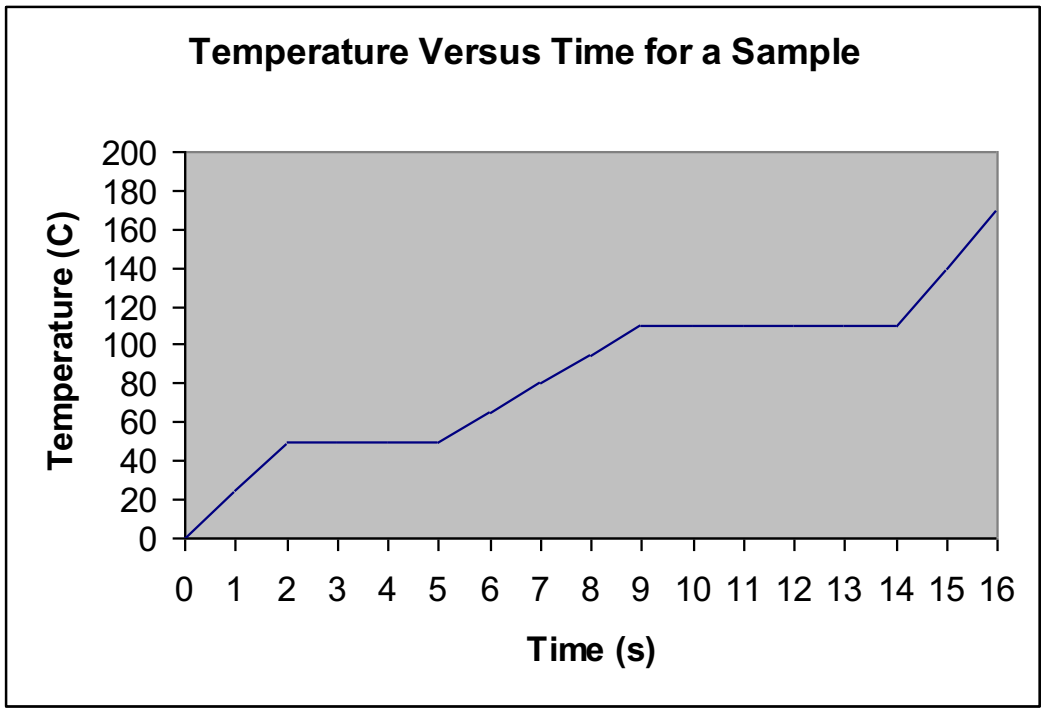
PART A: EXTENDED ANSWERS (50 marks – 50% of exam mark)

All work must be shown to obtain full marks. Attention must be paid to units.

I: Physical Properties of Matter (7 marks)

1. Starting as a solid, a sample of a substance is heated at a constant rate. The graph below shows the changes in temperature of this sample.



a) What is the melting point of this sample? (1 mark)

50° C

b) What is the boiling point of this sample? (1 mark)

110° C

c) What state is the sample in from 5 – 9 seconds? (1 mark)

Liquid

d) Explain why the temperature does not change from 9 – 14 seconds. (1 mark)

No change in kinetic energy – energy is used in phase change

2. Using your Vapour Pressure vs. Temperature for $CHCl_3$, CCl_4 and H_2O chart provided in your data booklet, answer the following questions.

   a) Under normal atmospheric conditions, which substance(s) would be boiling at 80°C? (1 mark)

   CCl_4 and $CHCl_3$ (1/2 mark each)

   b) State the atmospheric conditions necessary to enable water to boil at 60°C. (1 mark)

   20 kPa of atmosphere pressure

   c) In terms of average kinetic energy, differentiate between water at 20°C and water at 100°C. Assume normal atmospheric conditions for both samples. (1 mark)

   -H_2O @ 100˚C has a much higher average NRG
   -Temp is a direct measurement of K.E.

II: Gases and the Atmosphere (7 marks)

1. A helium balloon initially inflated to 2.50L at 100 kPa and 25.0°C is released and allowed to climb to a new altitude where the temperature is 10°C and the pressure is 25 kPa.
   a) What is the volume in Liters of the balloon at this height? (2 marks)

$V_1 = 2.50L$ **$V_2 = ?$** $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
$P_1 = 100KPa$ **$P_2 = 25KPa$**
$T_1 = 25^{\circ}C = 298\ K$ **$T_2 = 10^{\circ}C = 283\ K$** **(- ½ mark for no temp. conversion)**

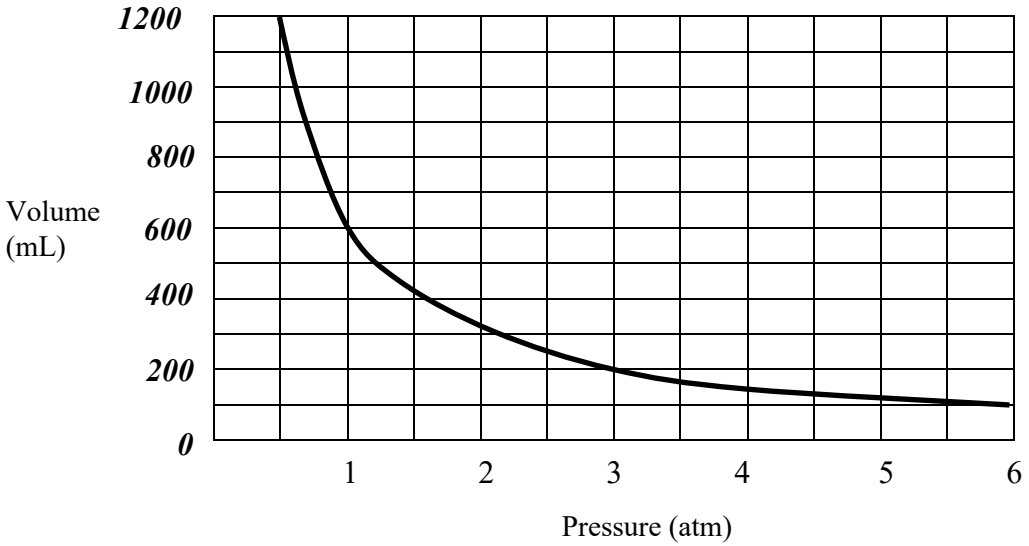
$$V_2 = \underbrace{\frac{P_1V_1T_2}{T_1P_2}}_{\text{1 mark}} = \underbrace{\frac{(100)(2.5)(283)}{(298)(25)}}_{\text{1 mark}} = 9.5L$$

   b) If the balloon has a maximum inflation volume of 10.0 L, will the balloon explode at this new height? (1 mark)

   No (1 mark) - only inflates to 9.5 L

2. A gas sample is held at constant temperature in a closed system. The volume of the gas is changed, which causes the pressure of the gas to change. Volume and pressure data are shown in the table below.

Volume (mL)	Pressure (atm)
1200	0.5
600	1.0
300	2.0
150	4.0
100	6.0



a) On the grid provided, mark an appropriate scale on the axis labeled "Volume (mL)". (1 mark)

SEE LABELED AXIS ABOVE – 1 MARK

b) On the same grid, plot the points and connect your points with a smooth line. (1 mark)

SEE GRAPH ABOVE – 1 MARK

c) Based on your graph, what is the pressure of the gas when the volume of the gas is 200 mL? (1 mark)

3 atm

d) Using Boyle's Law, calculate what final volume you would expect to find if your final pressure is 7 atm. You may choose any of the above sets of data to represent your initial pressure and volume. (1 mark)

$$P_1V_1 = P_2V_2 \qquad \frac{(1)(600)}{7} = \frac{7V_2}{7} \qquad V_2 = 85\text{L}$$

III: Chemical Reactions (16 marks)

1. A sample of krypton contains these isotopes.

Isotope	Percentage abundance
^{82}Kr	15.80
^{84}Kr	65.40
^{86}Kr	18.80

Calculate the relative atomic mass of krypton in this sample. Give your answer to **two** decimal places. All work must be shown for full marks. (2 marks)

(82)(0.1580) + (84 x 0.6540) + (86 x 0.1880) = 84.06 amu

Award 1 mark for substituted values. Award 1 mark for solution.
-½ mark units
-½ mark calculator error

2. Consider the reaction between aqueous hydrochloric acid (HCl) and solid calcium carbonate to produce water, carbon dioxide gas and aqueous calcium chloride.

Hydrochloric acid + calcium carbonate → water + carbon dioxide + calcium chloride

a) Write a balanced chemical equation for the reaction (2 marks)

$2HCl_{(aq)} + CaCO_{3(s)} \rightarrow H_2O_{(l)} + CO_{2(g)} + CaCl_{2(aq)}$
1 mark for equation
1 mark for balancing correctly
-1/2 mark for missing states

b) As this reaction is studied over time, it is noticed that a loss in mass has occurred. Explain why.

$CO_{2(g)}$ is produced and escapes (1 mark)

c) Another reaction occurs between calcium carbonate and iron (III) nitrate. Name and give the molecular formulas of the products in this double replacement reaction.

(2 marks)

Calcium Nitrate/ $Ca(NO_3)_2$
Iron (III) Carbonate/ $Fe_2(CO_3)_3$
Award 1 mark per product

3. An organic compound was analyzed and the following data were produced. In a 4.479 g sample;

Mass of carbon = 3.161 g
Mass of hydrogen = 0.266 g
Mass of oxygen = 1.052 g

a) Calculate the empirical formula for the organic compound. (3 marks)

nC = $\frac{3.161\text{g}}{12\text{g/ mol}}$ = 0.26341667 mol ½ mark

nH = $\frac{0.266\text{g}}{1.01\text{g/ mol}}$ = 0.2633633 mol ½ mark

nO = $\frac{1.052\text{g}}{16\text{g/ mol}}$ = 0.06575 mol ½ mark

C:H:O $\frac{0.263366}{0.06575}$ = 4 ½ mark
4:4:1

C_4H_4O 1 mark

b) If analysis revealed that the molar mass of the compound is 136 g/mol, determine the molecular formula for the compound. (1 mark)

$\frac{136}{68}$ = 2 ½ mark

$C_8H_8O_2$ ½ mark

Allow carry-on error. If work is correct award full marks.

4. Consider the reaction between zinc and copper (II) sulphate.

$$Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$$

a) Assuming that 27.5 g of zinc was combined with a solution that contains 60.5 g of copper (II) sulphate, determine the limiting reagent. Show all work for full marks.

$Zn(s) = 65.4g/mol$ **½ mark**

$CuSO_4(aq) = 159.5g/mol$ **½ mark**

(3 marks)

$nZn = \frac{27.5g}{65.4g/mol} = 0.4204$ mol **½ mark**

$nCuSO_4 = \frac{60.5g}{159.5g/mol} = 0.3793$ mol **½ mark**

1:1 Ratio ∴ $CuSO_4$ is the Limiting Reagent 1 **mark**

b) Calculate the mass of copper produced. (1 mark)

$$0.3793 \text{ mol } CuSO_4 \times \frac{1 \text{ mol Cu}}{1 \text{ mol } CuSO_4} \times \frac{63.5g}{1 \text{ mol Cu}} = 24.1 \text{ g}$$

c) If 19.3 g of copper was **actually** collected in the lab, determine the percent yield. (1 mark)

$$\% \text{ Yield} = \frac{19.3}{24.1} \times 100 = 80\% \text{ Yield}$$

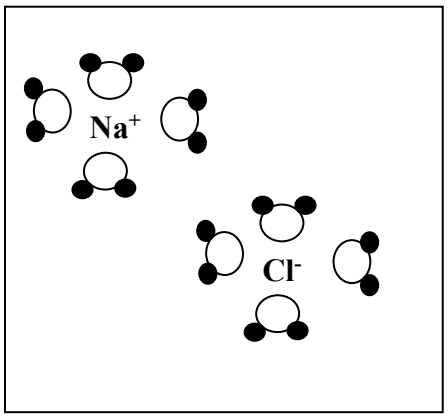
IV: Solutions (10 marks)

1. 5 g of sodium chloride, NaCl, is added to 50 ml of water in one beaker while 5 g of sugar, $C_6H_{12}O_6$, is added to 50 ml of water in another beaker.

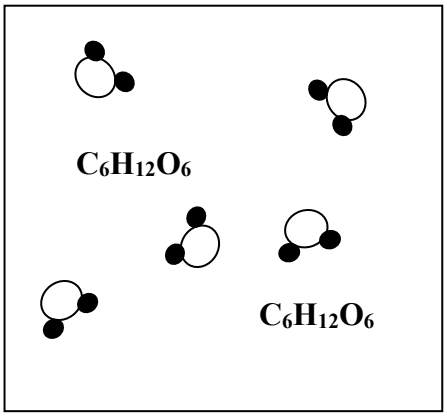
   a) Draw a molecular level diagram for each beaker. (2 marks)

   Award 1 mark for each correctly drawn diagram.

Salt Solution Molecular Diagram



Sugar Solution Molecular Diagram



 = Water Molecule

   b) Explain how the **two** solutes compare once dissolved in water. (2 marks)

   NaCl – $Na^+_{(aq)}$ & $Cl^-_{(aq)}$ - In solution (2 particles)

   $C_6H_{12}O_6$ - 1 particle in solution

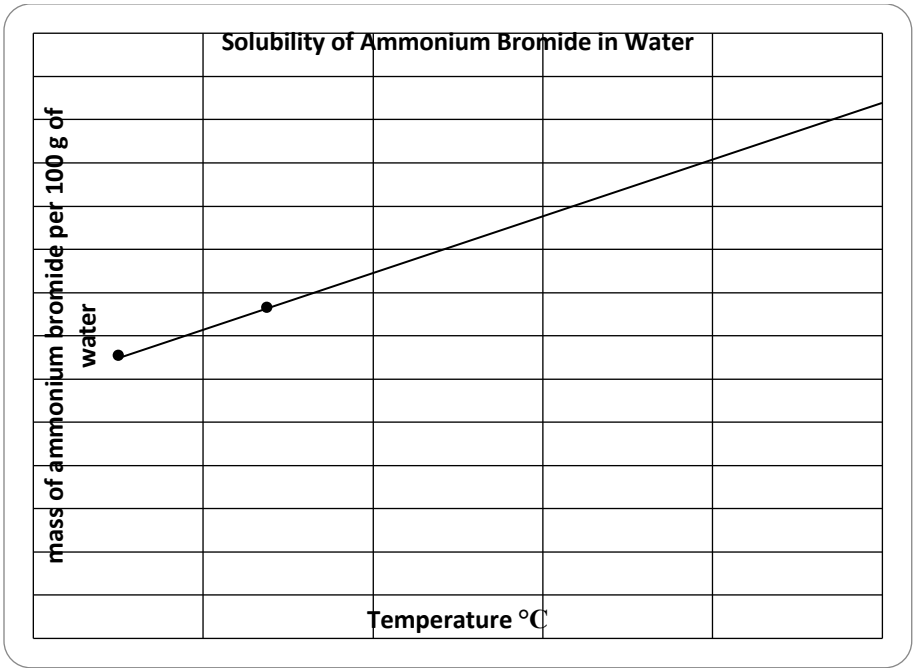
   c) State and explain how you would expect the boiling point of the two solutions to compare.
   (2 marks)

   NaCl is higher (1 mark) because more ions/particles in solution (1 mark)

2. The compounds ammonium bromide, $NH_4Br(s)$, and ammonia, $NH_3(g)$, are soluble in water. Solubility data for $NH_4Br(s)$ in water are listed in the table below.

Temperature ºC	Mass of ammonium bromide per 100 g of water
0	60
20	75
40	90
60	105
80	120
100	135

a) On the chart provided, plot the data and connect your points. (1 mark)



b) Determine the mass of NH_4Br that must be dissolved in 250 g of water at 60ºC to produce a saturated solution. (1 mark)

$$\frac{105\text{g}}{100\text{g } H_2O} \times 250\text{g } H_2O = 262.5\text{g } NH_4Br$$

c) Recalling your understanding of solubility of a gas at varied temperatures, compare the solubilities of **$NH_4Br(s)$** and **$NH_3(g)$**, each in 100. grams of H_2O, as temperature increases at standard pressure. (1 mark)

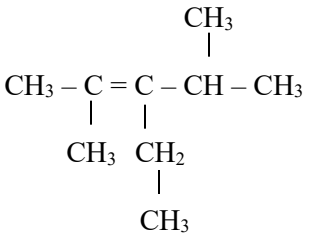
NH_4Br – solubility increases ½ mark
NH_3 – solubility decreases ½ mark

d) Explain your expected results from part c, making reference to the nature of the solute particles. (1 mark)
NH_4Br – solid – solubility ↑ with ↑ in temp (½ mark)
NH_3 – gas – solubility ↓ with ↑in temp (½ mark)

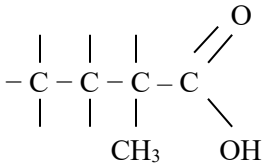
V: Organic Chemistry (10 marks)

1. Draw the following organic compounds. (1 mark each = 2 marks)

   a) 3-ethyl-2,4-dimethylpent-2-ene (3-ethyl-2.4-dimethyl-2-pentene)



   b) 2-methyl-butanoic acid



2. Use the following data table for this question.

Formulas and Boiling Points Of Selected Alkenes

Name	Formula	Boiling Point at 1atm (ºC)
Methane	CH_4	-162
Ethane	C_2H_6	-89
Propane	C_3H_8	-42
Butane	C_4H_{10}	-0.5
Pentane	C_5H_{12}	36

   a) State and explain the trend in boiling points for the first 5 alkanes. (2 marks)

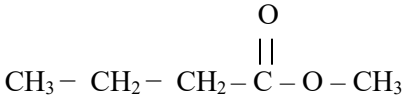
- **Increase in B.P. (1 mark)**
- **Longer chains/ Higher melting rate/Stronger Van Der Waals Forces (IMF's) (1 mark)**

   b) At standard pressure and 23˚C, which alkane is a liquid? (1 mark)

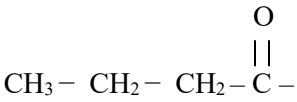
Pentane

3. Methyl butanoate is the ester responsible for an apples aroma.

a) Draw the structure of methyl butanoate. (1 mark)



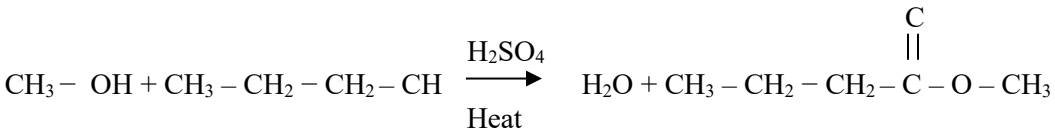
b) Draw structures and name the **two** reactants responsible for producing methyl butanoate. (2 marks)



- Butanoic Acid (1 mark)

$CH_3 - OH$ - Methanol (1 mark)

c) Write a complete reaction for the production of methyl butanoate. Be sure to include all conditions necessary for the reaction to take place. (2 marks)



Deduct 1/2 mark for missing H_2SO_4/ heat
Deduct 1/2 mark for missing H_2O