PART A: EXTENDED ANSWERS (30 marks – 40% of exam mark)

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

I: Physical Properties of Matter (4 marks)

1. At sea level and under standard temperature and pressure conditions, water will boil at 100°C while ethanol will boil at 78°C. State which of the two has the **higher** vapour pressure and explain why.

(1 mark)

Answer: ***Ethanol – Award ½ mark.***

Explanation

Ethanol has a lower boiling point – Award ½ mark.

2. List two factors that affect the rate of evaporation. (1 mark)

Evaporation rate depends on the temperature of the liquid, how tightly the liquid molecules bond to each other, the surface area of the liquid, and the temperature, pressure, and air movements in the surroundings into which evaporation occurs.

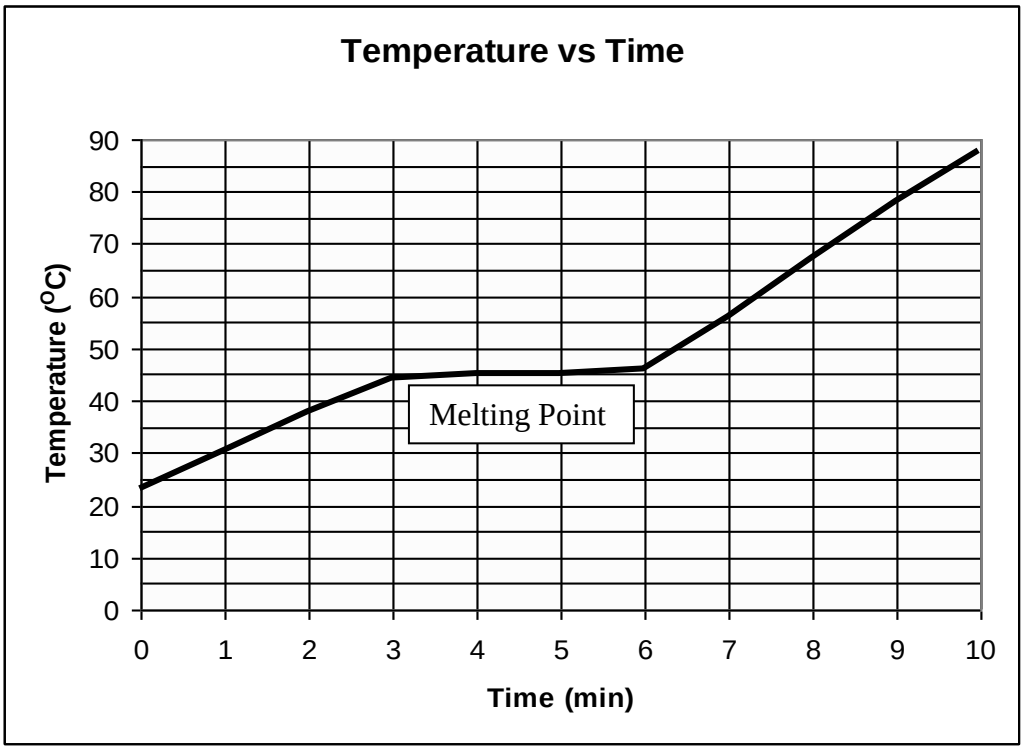
The warmer the liquid, the faster the evaporation rate. The stronger the molecules bond to each other, the slower the evaporation rate. The larger the exposed surface, the faster the evaporation rate. The colder the surroundings, the faster the evaporation rate. The lower the atmospheric pressure above the liquid, the faster the evaporation rate. The faster the air above the liquid moves, the faster the evaporation rate.

Award ½ mark for each correctly identified factor for a total of 1 mark. If more than two factors are listed – score only the first two.

3. The following data were collected upon heating Lauric Acid:

Time (min)	Temperature (°C)
0	23
1	30
2	37
3	44
4	45
5	45
6	46
7	56
8	67
9	78
10	88

a) Plot and graph the data on the grid below. (1 mark)
b) Label the melting point on the graph (0.5 mark)



c) Explain at the molecular level, why the temperature is not changing significantly from 3 – 6 minutes. (0.5 mark)

Energy from heat is used in phase change (solid to liquid).

II: Gases and the Atmosphere (4 marks)

1. Describe the contribution made by one of the following chemists in the measurement of pressure: (2 marks)

John Dalton Joseph Louis Gay-Lussac Amadeo Avogadro

1801: John Dalton stated that in a mixture of gases the **total pressure is equal to the sum of the pressure of each gas**, as if it were in a container alone. The pressure exerted by each gas is called its **partial pressure**. ($P_{total} = p_1 + p_2 + \ldots + P_n$; where p_1, p_2, p_n represent the partial pressure of each component)

1808: Joseph Louis Gay-Lussac observed the **law of combining volumes**. He noticed that, for example, two volumes of hydrogen combined with one volume of oxygen to form two volumes of water (The ratio between the volumes of the reactant gases and the products can be expressed in simple whole numbers). He also noticed that the pressure of a fixed mass and fixed volume of a gas is **directly proportional to the gas's temperature** ($P \sim T$; $P_1/T_1 = P_2/T_2$)

1811: Amadeo Avogadro suggested, from Gay-Lussac's experiments conducted three years earlier, that the **pressure in a container is directly proportional to the number of particles in that container** (Avogadro's Hypothesis; Avogadro's Law). The most significant consequence of Avogadro's law is that the ideal gas constant has the **same value for all gases** ($PV = nRT$).

Award 1 mark for each bold statement. If more than one chemist is described, score only the first chemist presented.

2. A syringe containing a sample of gas is heated from 100 K and the following data were collected.

Temperature (K)	Volume (ml)
100	8.75
200	17.45
300	26.17
400	34.89

a) Based on the data, describe the relationship that exists between the temperature and the volume of the gas. (0.5 mark)

As the temperature increases, volume increases.

b) Explain what happens to the gas particles when they are heated. (0.5 mark)

Begin to move faster with an increase in heat (KE).

c) If the gas was heated to 427 ºC, what volume would this gas occupy? (1 mark)

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad \Rightarrow \quad \frac{17.45}{200} = \frac{V_2}{700} \quad \therefore V_2 = 61.08\ mL$$

Award ½ mark for temperature to Kelvin conversion and ½ mark for solution.

III: Chemical Reactions (10 marks)

1. Germanium has five naturally occurring isotopes with the following data.

Mass (amu)	Percent (%) abundance
70	20
71	27
72	8
73	37
74	8

Use the information in the table to calculate the average atomic mass of Germanium. Show all calculations to receive full credit. (2 marks)

(70x0.2)+(71x0.27)+(72x0.08)+(73x0.37)+(74x0.08) = 71.86 amu (Award 1 mark)

Deduct ½ mark for one procedural error.
Deduct 1 mark for two procedural errors.
Deduct 1.5 marks for three procedural errors.
Award 1 mark for answer if math is correct.

2. Aqueous Lead (II) nitrate is combined with aqueous potassium iodide in a double replacement reaction. A yellow solid is one of the products.

a) Identify the products formed. (1 mark)

PbI_2 (Award ½ mark) and KNO_3 (Award ½ mark)

b) Write the balanced chemical equation, including state symbols. (1.5 marks)

$Pb(NO_3)_{2(aq)} + 2KI_{(aq)} \Longrightarrow PbI_{2(s)} + 2KNO_{3(aq)}$

Award ½ mark for correct states.
Award ½ mark for correct reactants and ½ mark for correct products

3. If 2.476 g of an oxide of copper is found to contain 2.199 g of copper, determine:

a) the empirical formula. (2 marks)

$_m$Cu = 2.199g ***$_m$O = 0.277g***

$_m$Cu = 2.199g/63.55 ***$_m$O = 0.277g/16***

$_m$Cu = 0.034603 mol Cu (Award ½ mark)

$_m$O = 0.0173125 mol O (Award ½ mark)

0.034603/0.0173125 = 2 (Award ½ mark)

Cu_2O (Award ½ mark)

b) the name of the compound. (0.5 mark)

Copper (1) oxide

4. Use the following reaction used to obtain hydrogen gas from magnesium and hydrochloric acid:

$$Mg_{(s)} + 2HCl_{(aq)} \rightarrow H_{2(g)} + MgCl_{2(aq)}$$

50 ml of 6 mol/L HCl is combined with 3 g of Mg to produce 2.45 L H_2 gas.

a) Determine the limiting reactant. (1.5 marks)

${}_nMg = 3/24.3 = 0.1234567$ (Award ½ mark)

${}_nHCl = 0.05\ L \times 6\ mol/L = 0.3\ mol$ (Award ½ mark)

0.1234567 mol Mg x (2 mol HCl/1 mol Mg) = 0.2468 mol HCl needed

Therefore, Mg is the limiting reactant.
(Award ½ mark)

b) Calculate the theoretical yield of hydrogen gas assuming STP Conditions. (1 mark)

0.1234567 mol Mg x (1 mol H_2/ 1 mol Mg) x (22.4 L/1 mol H_2) = 2.77 L
(Award ½ mark) (Award ½ mark)

c) Calculate the percent yield of H_2. (0.5 mark)

% Yield = 2.45 L/2.77 L = 88.5%

IV: Solutions (6 marks)

1. Which of the following salts would be most effective for reducing icy road conditions? Explain why. (2 marks)

$AlCl_3$ LiCl $CaCl_2$

Answer: ***$AlCl_3$ (Award 1 mark)***

Explanation: ***$AlCl_3$ produces the most ions in solution to break down the ice.***

(Award 1 mark)

2. Explain why hot water has the ability to dissolve more salt (NaCl) compared to an equal volume of water that is at a much cooler temperature. A labeled diagram may be used to help with your explanation. (1 mark)

Hot Water – Particles have high energy and collide more frequently/ more energy with salt. (Award ½ mark)

Cold Water – Particles have low energy and collide less frequently/collisions less effective. (Award ½ mark)

3. Use the solubility curve in your data booklet for the next three questions.

a) If a 200 ml saturated solution of sodium nitrate ($NaNO_3$) is prepared at 80°C, calculate how much sodium nitrate will settle out if the solution is cooled to 10°C. (1 mark)

145g $NaNO_3$/100g H_2O @ 80°C 79g $NaNO_3$/100g H_2O @10°C

145 – 79 = 66g/100g H_2O (Award ½ mark)

Therefore, 132g precipitated in 200 mL solution. (Award ½ mark)

b) 10 g of Ammonium chloride (NH_4Cl) is prepared in 25 ml of water at 50°C. State and explain whether the solution would be saturated, supersaturated, or unsaturated. (1 mark)

Answer: ***Unsaturated (Award ½ mark)***

Explanation: ***Below saturate line; (10g/25mL = 40g/100 mL) (Award ½ mark)***

c) State what happens to the solubility of a gas as the temperature of the solution increases. Explain why at the molecular level. (1 mark)

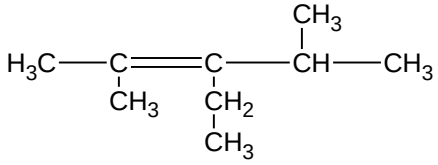
Answer: ***Solubility decreases. (Award ½ mark)***

Explanation: ***As temperature increases, solvent has more energy ; particles collide more frequently with gas particles – knocking them out of solution. (Award ½ mark)***

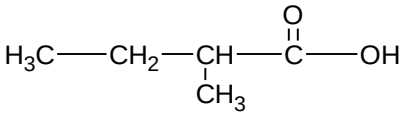
V: Organic Chemistry (6 marks)

1. Write the name for the following organic compounds.

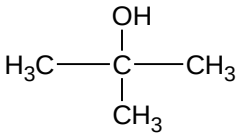
(0.5 mark each x 3 = 1.5 marks)

a) 

3-ethyl-2,4-dimethyl-2-pentene
(3-ethyl-2,4-dimethyl-pent-2-ene)

b) 

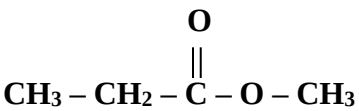
2-methyl butanoic acid

c) 

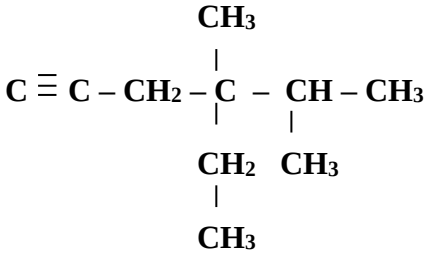
2-methyl-2-propanol
(2-methyl-propan-2-ol)

2. Draw the molecule for the following organic compounds in the space provided:

a) Methyl Propanoate (0.5 mark)



b) 4-ethyl-4,5-dimethyl-hex-1-yne (0.5 mark)



3. Draw the reaction, showing structures, for the reaction between pentanoic acid and 1-propanol. Be sure to show all conditions necessary for the reaction to take place (catalyst, etc.) and name the products. (2 marks)

$$CH_3 - CH_2 - CH_2 - CH_2 - C - OH \; + \; HO - CH_2 - CH_2 - CH_3 \xrightarrow[\text{Heat}]{H_2SO_4}$$

$$H_2O + CH_3 - CH_2 - CH_2 - CH_2 - \overset{\overset{O}{\|}}{C} - C - OH_2 - OH_2 - OH$$

(Water) (Propyl Pentanoate)

Award ½ mark for correct identifying conditions.
Award ½ mark for reactant formulas.
Award ½ mark for product formulas.
Award ½ mark for product names.

4. Name and draw all the structural isomers of pentane C_5H_{12}. (1.5 marks)

$CH_3 - CH_2 - CH_2 - CH_2 - CH_3$ **Pentane**

$CH_3 - \underset{\underset{CH_3}{|}}{CH} - CH_2 - CH_3$ **2 – methyl-butane**

$CH_3 - \underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}} - CH_3$ **2,2 – dimethylpropane**

PART B: Multiple Choice (50 marks – 60% of exam mark)

Question	Answer		Question	Answer
1	B		30	B
2	D		31	C
3	A		32	D
4	D		33	A
5	B		34	A
6	A		35	B
7	A		36	C
8	B		37	A
9	B		38	D
10	C		39	D
11	A		40	B
12	C		41	B
13	A		42	B
14	B		43	D
15	C		44	A
16	C		45	C
17	D		46	A
18	A		47	D
19	B		48	B
20	D		49	C
21	A		50	C
22	D			
23	D			
24	B			
25	A			
26	B			
27	D			
28	A			
29	D			