Section A

1 Antimony (Sb), with atomic number 51 has been known since about 4000BC. Nowadays, its main use is to harden and to strengthen lead alloys.

A typical sample of antimony consists of two isotopes and has the following composition by mass: ^{121}Sb, 57.25%, ^{123}Sb, 42.75%.

(a) (i) Calculate the *relative atomic mass* of the antimony sample.

Relative atomic mass = (57.25 x 121 + 42.75 x 123) / 100 = 121.9

(II) Define the term *relative atomic mass*.

Relative mass of a particle (egs. atom, molecule, ion, etc.) is defined as the number of times the particle is heavier than the mass of an atom of carbon–12.

[3]

Antimony is produced in two-stage process from the sulphide ore, Sb_2S_3.

The ore is first roasted in oxygen to form the oxide.

$2Sb_2S_3(s) + 9O_2(g) \rightarrow Sb_4O_6(s) + 6SO_2(g)$

The oxide is then reduced with carbon.

$Sb_4O_6(s) + 3C(s) \rightarrow 4Sb(s) + 3CO_2(g)$

(b) Showing your working clearly, calculate the volume of carbon dioxide at room temperature and pressure that would be produced by the processing of 3400 g of Sb_2S_3.

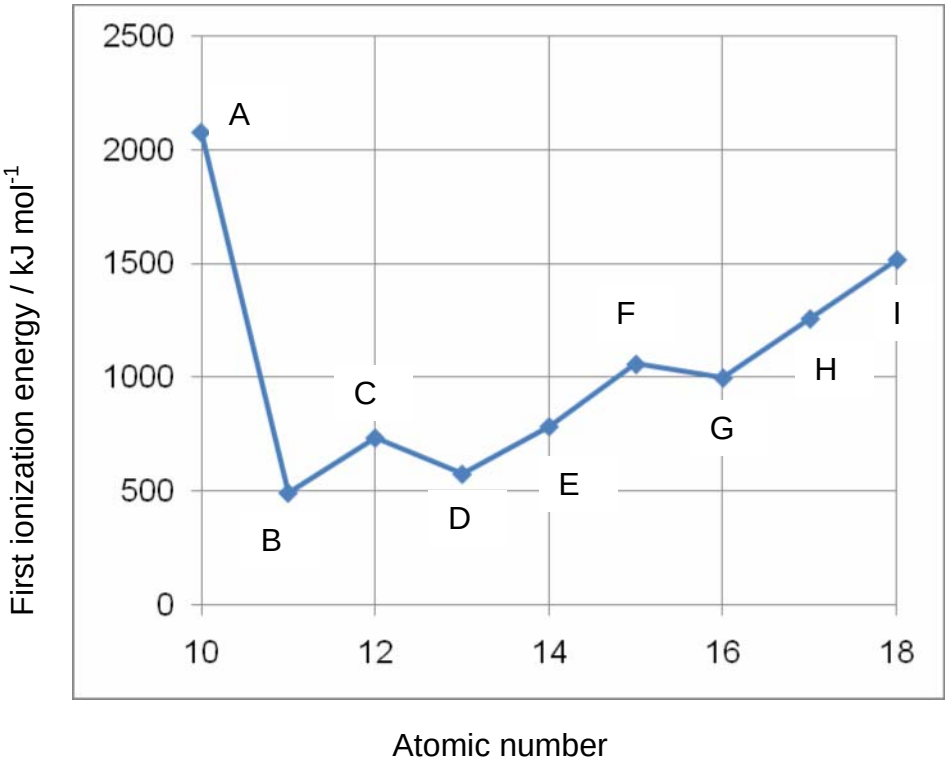
$2\ Sb_2S_3 = S_4O_6 = 3\ CO_2$
No. of mol of CO_2 = 3/2 x 3400/(340.1) = 15.0 mols
Volume of CO_2 = 15 x 24dm^3 = 360 dm^3

[3]

[Total: 6 marks]

Section A

2 The figure shows a plot of first ionisation energy against atomic number for the elements of atomic number 10 to 18. (The letters are not the chemical symbols for the elements concerned.)



(a) Write an equation to define the first ionization energy of **A**.

$A(g) \rightarrow A^{+}(g) + e$ [1]

(b) (i) Describe the **general trend** of the ionization energies from **B** to **I** as shown in the graph above.

The successive I.E. from B to I **generally increases**. **Nuclear charge increases** when electrons are removed and there are **stronger electrostatic forces of attraction between nucleus and valence electrons. Therefore more energy** is required to remove the remaining electrons.

[2]

(ii) Explain briefly why the first ionization energy of D is less than C.

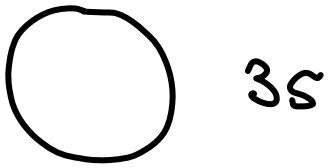
The first ionisation energy of D involves the removal of a **3p** electron whereas first I.E of C involves the removal of a **3s** electron. **Smaller** amount of energy is required to remove the **3p** electron in D which is

further from the nucleus than **3s** electron in C.

[2]

(b) Draw the shape of the orbital from which electron is lost when

(i) Element **B** forms a singly charged ion,



(ii) Element **H** forms a singly charged ion.

[2]

(c) Give the full electronic configuration of the element labeled **F**.
$1s^2 2s^2 2p^6 3s^2 3p^3$

[1]

[Total:8 marks]

3 Each of these elements in Period 3 will react with oxygen given suitable conditions.

Period 3	Na	Mg	Al	Si	P	S	Cl

(a) Which element(s) can exist

(i) as diatomic molecules at room temperature,

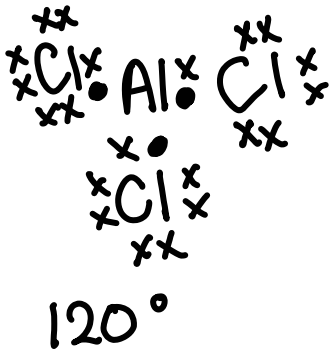
Chlorine

(ii) as macromolecular structures?

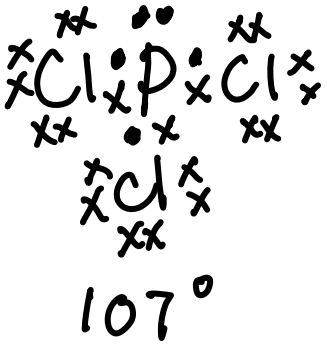
Silicon

[2]

(b) Two elements form chlorides with formulae of the type XCl_3. Draw the dot-and-cross diagram for these two chlorides, state the shape and suggest values for the bond angles.



Trigonal planar



Trigonal pyramidal

[4]

(c) (i) One element form chloride of the type YCl_2 which reacts with water to give a slightly acidic solution. Name the element, and account for the pH value of YCl_2 in water. Write balanced equation to illustrate your answer.

Magnesium. The pH is about **6.5** as Mg^{2+} can **hydrolyse** in water to produce a slightly acidic solution.

$[Mg(H_2O)_6]^{2+} + H_2O \leftrightarrow [Mg(H_2O)_5(OH)]^+ + H_3O^+$

(ii) One element forms a chloride of the type ZCl_4, which reacts with water to give a strongly acidic solution. Name the element and write a balanced equation for the chloride reacting with water.

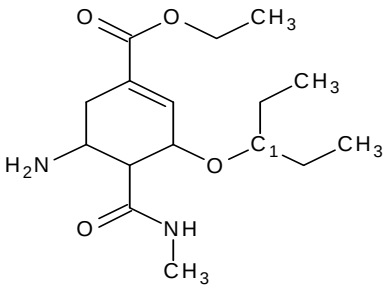
The element is silicon.

$SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$

[5]

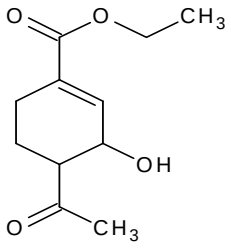
[Total: 11 marks]

4 **Oseltamivir** (Tamiflu) is an antiviral drug that slows the spread of non-resistant strains of the influenza virus between cells in the body. It blocks the action of a viral enzyme called neuraminidase and has since been indicated for the treatment of H5N1 and H1N1 infection. The standard adult dosage is 75mg twice daily. Compound **Z** is a derivative of **oseltamivir** that maybe investigated for antiviral activities.



Oseltamivir

M_r : 312.4



Z

(a) (i) A male adult patient has been put on a 5-day tamiflu treatment. Calculate the total number of moles of tamiflu taken by this patient over this period of treatment.

No of moles = $(75 \times 10^{-3})/312.4 \times 2 \times 5$
= 0.00240 (3sf)

[1]

(ii) Describe the hybridisation, geometry and bond angle about C_1 atom.

sp^3
tetrahedral
109.5°

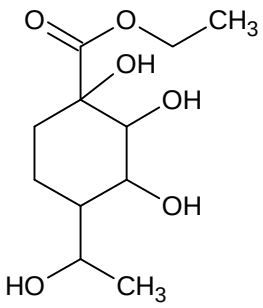
[3]

(iii) Name the functional groups present in Compound **Z**.

Ester, alkene, secondary alcohol, ketone.

[2]

(iv) Compound **X** can be synthesised from **Z** using 2 consecutive reactions. Give the reagents and conditions for both reactions. Name the type of reactions involved.



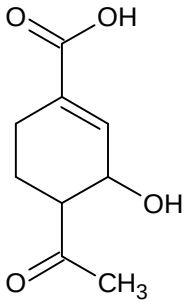
X

Step I: Reagent: **cold**, dilute MnO_4^- in OH^- (aq)
Condition: room temperature
Type of reaction: oxidation

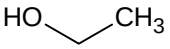
Step II: Reagent: $NaBH_4$ in methanolic solution
Condition: room temperature
Type of reaction: reduction

[3]

(v) Draw the products formed when Compound **Z** is reacted with dilute HC*l* under reflex.



1

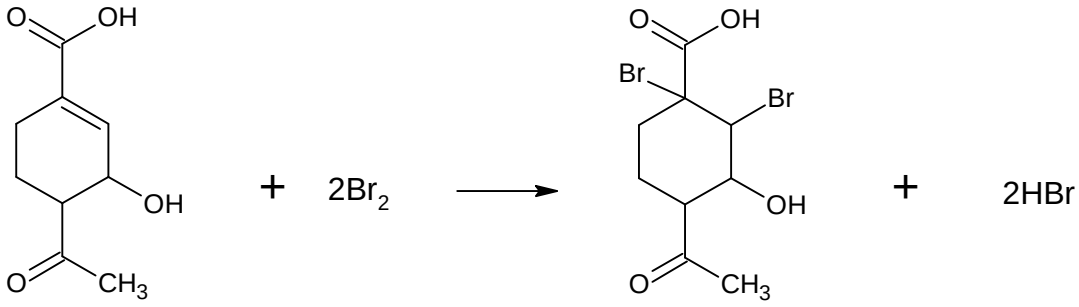


1

[2]

(vi) Describe a chemical test to distinguish the products from **(v)**. State the observations with each compound and write balanced equation(s) for reaction(s) involved.

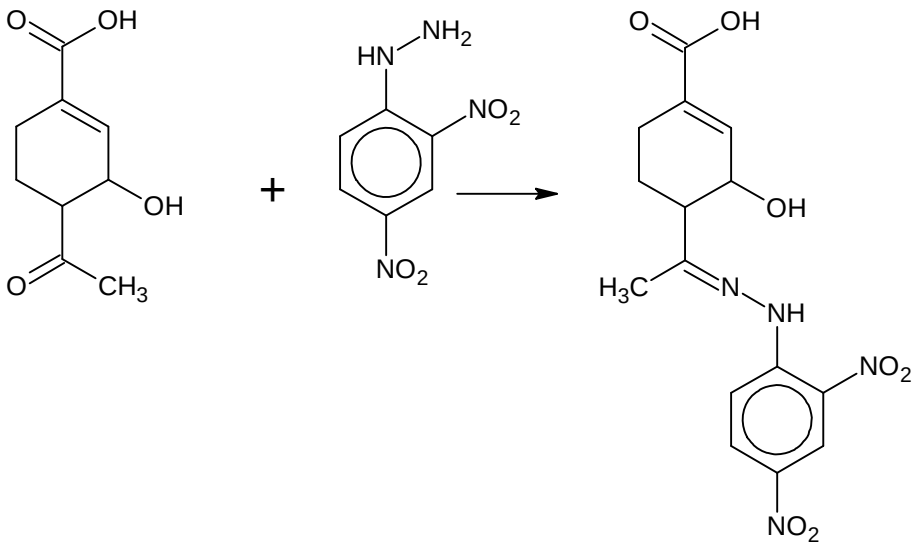
Test: Add **Br_2/CCl_4** in the **absence of light** at **room temperature** to both products.
Observations:
For big molecule: **Decolourisation of reddish-brown solution** seen.
For ethanol: **No decolourisation** observed.
Note: Do not accept **'No visible change'** for negative observations.
Equation:



1

OR

Test: Add **2,4 DNPH** at **room temperature** to both products.
Observations:
For big molecule: **Orange ppt** seen.
For ethanol: **No orange ppt** observed.
Note: Do not accept **'No visible change'** for negative observations.
Equation:



1

[4]

Total: [15 marks]

P2 Section B Mark Scheme

1(a)(i) $[H^+] = 10^{-3.5} = 3.16 \times 10^{-4}$ mol dm^{-3}

(ii) No. of mol of NaOH = $\frac{21.25}{1000} \times 0.25 = 5.312 \times 10^{-3}$
= No. of mol of HA

$$[HA] = \frac{5.312 \times 10^{-3}}{\frac{25}{1000}} = 0.2125 = 0.213 \text{ mol dm}^{-3}$$

(iii) HA is a **weak acid**.
Since **[HA] >>[H^+]**, HA **dissociates partially / incompletely** to form H^+.

(iv) phenolphthalein

(b) (i) $K_C = \frac{[CH_3CH_2COOCH_2CH_3]\ [H_2O]}{[CH_3CH_2COOH][CH_3CH_2OH]}$

(ii) 5 min

(iii) $K_C = \frac{[0.07][0.07]}{[0.03][0.01]} = 16.3$

(iv) When temperature increases, by **Le Chatelier's Principle**, the equilibrium shifts **left** to favour the backward **endothermic reaction** so as to **absorb / remove heat**. Hence the **yield of the ester decreases**. **K_c value decreases**

(c) (i) A solution that **maintains a fairly constant pH / resists pH changes** when a **small amount of acid or base is added** to it.

(ii) When a small amount of H^+ is added,
$CH_3CH_2COO^- + H^+ \rightarrow CH_3CH_2COOH$
The added **H^+** is **removed** as CH_3CH_2COOH
Hence pH **remains fairly constant**

When a small amount of OH^- is added,
$CH_3CH_2COOH + OH^- \rightarrow CH_3CH_2COO^- + H_2O$
The added **OH^-** is **removed** as $CH_3CH_2COO^-$,
Hence pH **remains fairly constant**

(d)(i) Chain Isomerism

$CH_3COOCH_2CH_2CH_3$

Functional group Isomerism

$CH_3CH_2CH_2CH_2COOH$

(d)(ii) Reagent&Condition: 1) Use Na metal/RT 2) Use Na_2CO_3/RT

1) Effervescence of a colourless and odourless gas which extinguishes the lighted splint with a "pop" sound for acid. No gas evolved for ester.

2) Effervescence of a colourless and odourless gas which turned limewater chalky/formed a white ppt with limewater. No gas evolved for ester.

2(a)(i) **Pressure** can be monitored as there is a **change in number of moles of gas**

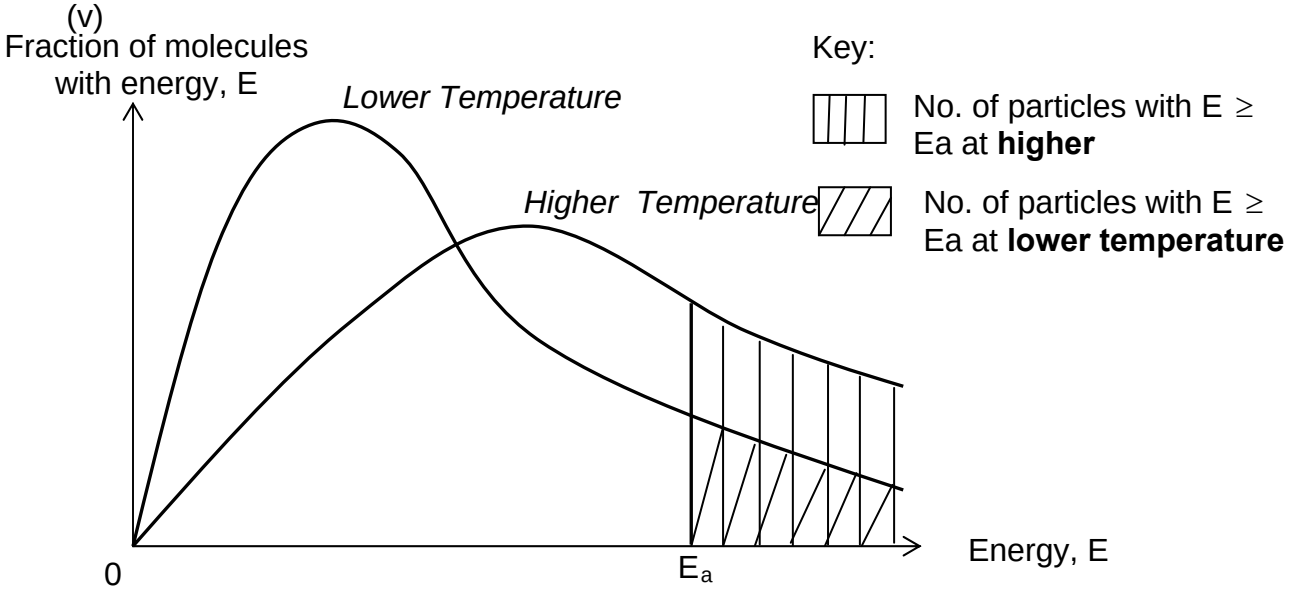
(ii) By comparing experiments 1 and 2:
As $[CH_3CH_3]$ is kept constant, the initial rate remains constant as $[N_2]$ increases by 2 times. Therefore, the reaction is **zero order** w.r.t N_2.

By comparing experiments 1 and 3:
As $[N_2]$ is kept constant, the initial rate decreases by 2 times as $[CH_3CH_3]$ increases by 2 times. Therefore, the reaction is **first order** w.r.t CH_3CH_3.

(iii) By using data from Experiment 1,
$0.002 = k\ (0.005)$
$k = 0.4\ s^{-1}$

(iv) Bonds broken = 2 (C–N) + N=N
= 2(305) + 410 = **1020 kJ mol^{-1}**
Bonds formed = (C–C) + N_N
= 350 + 994 = **1344 kJ mol^{-1}**
ΔH_{rxn} = 1020 – 1344
= **– 324 kJ mol^{-1}**

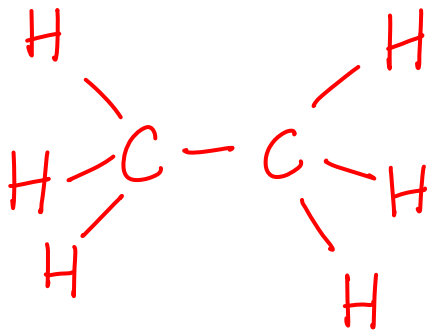
(v)



For marking of graph
Correct key and shading of graphs
Correct axes labeled
Correct labeling of graphs
Indication of E_a on the x-axis
Graph must start from origin

When temperature of the reaction **decreases**,
- ✓ **average kinetic energy** of the reacting molecules **decreases**
- ✓ **number** of **effective collisions with $E \geq E_a$** taking place in the reaction **decreases**
- ✓ rate of reaction is **proportional** to the **frequency of effective collisions**
- ✓ **rate of reaction decreases**

(b)(i)



Shape: **Tetrahedral** about each C atom.

(ii) Ethane has a **simple molecular** structure with **weak VDW forces of attraction.** Therefore, **small amount of energy** is required to overcome the weak VDW forces of attraction and hence, **lower boiling point**

(c)(i) **P**: **CH_3CH_2Cl**
Q: **CH_3CH_2CN**

(ii) Step **II**
Reagent: **Alcoholic KCN**
Condition: **Reflux**

Step **III**
Reagent: **Dilute H_2SO_4 / HCl**
Condition: **Reflux**

3(a)(i)

A = $CH_3CH(OH)CH_3$
C = CH_3COCH_3
B = $CH_3CH_2CH_2OH$
D = CH_3CH_2CHO
E = CH_3CH_2COOH

(ii)

F = $CH_3CH_2COCH_3$
G = $CH_3CH_2CH_2CHO$ or $(CH_3)_2CHCHO$

(iii)

H = CH_3CO_2H
I = HCO_2CH_3

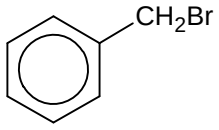
(b)(i) **Oxidation**
Reagents: **acidified $KMnO_4$**
Conditions: **reflux**

(ii) **Elimination**
Reagents: **Alcoholic KOH/NaOH**
Conditions: **Reflux**

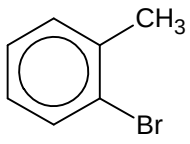
(iii) **Reduction**
Reagents: **$LiAlH_4$ in dry ether**
Conditions: **Room temperature**

(iv) **Substitution**
Reagents: PCl_5 or $SOCl_2$
Conditions: **Room temp**

(c) Reaction in the side chain: **UV light**

Product: 

Reaction in the ring: **FeBr3 as catalyst, room temperature**

Product: 

or