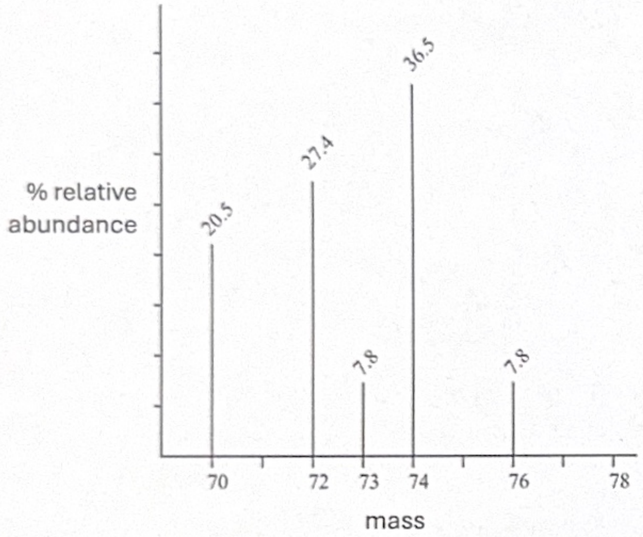
1 Germanium is an element in Group 14. It is used as a semiconductor in transistors and various other electronic devices.

(a) A sample of germanium is analysed using a mass spectrometer. The mass spectrum produced is shown.



(i) Explain what is meant by the term relative atomic mass.

The ~~mass~~ mass of an atom related to $\frac{1}{12}$ carbon atom

~~mass~~ number ~~with~~ caculated with relative abundance.

[2]

(ii) Calculate the relative atomic mass of gallium in this sample.

Give your answer to one decimal place.

Show your working.

70 x 20.5 + 27.4 x 72 + 73 x 7.8 + 74 x 36.5 + 76 x 7.8

= 72.71

7271 ÷ 100 = 72.71

relative atomic mass = 72.71

[2]

(b) Complete the table which describes a gaseous atom of germanium.

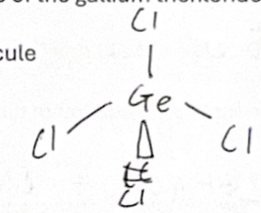
isotope	nucleon number	total number of electrons in **lowest** energy level	type of orbital which contains the electron in the **highest** energy level
^{74}Ge	74	2	p

[3]

(c) When germanium is heated in excess chlorine, germanium tetrachloride, $GeCl_4$, is made.

Draw the shape of the gallium trichloride molecule and suggest the Cl–Ge–Cl bond angle.

shape of molecule



bond angle 109.5°

[2]

(d) Gemanium oxide, GeO_2, will react with hot concentrated acids and molten alkalis.

(i) Suggest the equation for the reaction between GeO_2 and HNO_3.

$GeO_2 + 4HNO \rightarrow$ ~~$2H_2O$~~ ~~+ $Ge(NO_3)_4$~~

$2NO + Ge(NO)_2 + 2H_2O$

[1]

(ii) Suggest an equation for the reaction between germanium oxide and NaOH.

$GeO_2 + 2NaOH \rightarrow Ge(NaO)_2 + H_2 + O_2$

[2]

[Total: 12]

2 Nitric acid can be made from ammonia in a 3-stage process.

Stage 1 Ammonia is oxidised by oxygen from the air, to form nitrogen monoxide and water. This reaction is carried out at 8 kPa and 900 °C in the presence of a platinum catalyst.

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O \quad \Delta H = -905 \text{ kJ mol}^{-1}$$

Stage 2 Nitrogen monoxide is cooled to 250 °C and reacts with more oxygen to form nitrogen dioxide.

$$2NO + O_2 \rightarrow 2NO_2 \quad \Delta H = -114 \text{ kJ mol}^{-1}$$

Stage 3 Nitrogen dioxide reacts with water to make nitric acid and nitrogen monoxide.

$$\overset{+4}{3NO_2} + H_2O \rightarrow 2\overset{+5}{HNO_3} + \overset{+2}{NO} \quad \Delta H = -117 \text{ kJ mol}^{-1}$$

(a) (i) Construct an overall balanced equation for the production of nitric acid from ammonia and oxygen.

$3NH_3 + 3O_2 \rightarrow 2HNO_3 + NO$

[1]

(ii) Calculate the overall enthalpy change for the production of 1 mole of nitric acid.

$-905 \times 3 \quad -114 \times 6 \quad -117 \times 4$

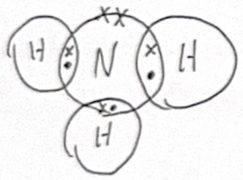
$12\ 4 \rightarrow 12\ NO \rightarrow 12\ NO_2 \rightarrow 8\ HNO_3$

$$\frac{-905 \times 3 + -114 \times 6 + -117 \times 4}{8} = -483.375$$

$= -483 \text{ kJ mol}^{-1}$

[1]

(b) Draw a 'dot-and-cross' diagram to show the arrangement of outer electrons in a molecule of ammonia.



[1]

(c) (i) Give the oxidation numbers of nitrogen in the nitrogen-containing species for the reaction in **stage 3**.

NO_2 +4

HNO_3 +5

NO +2

[2]

(ii) Explain why the reaction in stage 3 is described as a disproportionation reaction. Include reference to transfer of electrons in your answer.

[2]

(d) Identify one natural and one man-made occurrence of nitrogen oxides in the atmosphere.

natural ~~N_2~~ NO

man-made ~~NH_3~~ NO_2

[2]

(e) Ammonia is a basic gas.

Describe how ammonia is able to act as a base.

Because it is able to ~~be~~ accept proton

[1]

[Total: 10]

3 The Group 16 elements show a change from non-metallic to metallic character down the group.

(a) Table 3.1 shows some properties of two Group 16 elements, O and Te, in their standard states. The table is incomplete.

Table 3.1

	oxygen	tellurium
state and appearance in standard state	colourless gas	silvery solid
electrical conductivity	~~none~~ bad	good
type of bonding	covalent	metallic
type of structure	simple	giant lattice

(iii) Complete table 3.1. [3]

(iv) Explain why tellurium has good electrical conductivity.

It is metallic bond containing many free electrons that make it ~~can~~ conductive.

[1]

(v) Tellurium has two allotropes. Define allotrope.

Different structure with same atom.

[1]

(b) Fig. 3.2 shows the boiling points of the simplest hydrides of the Group 16 elements, O to Te.

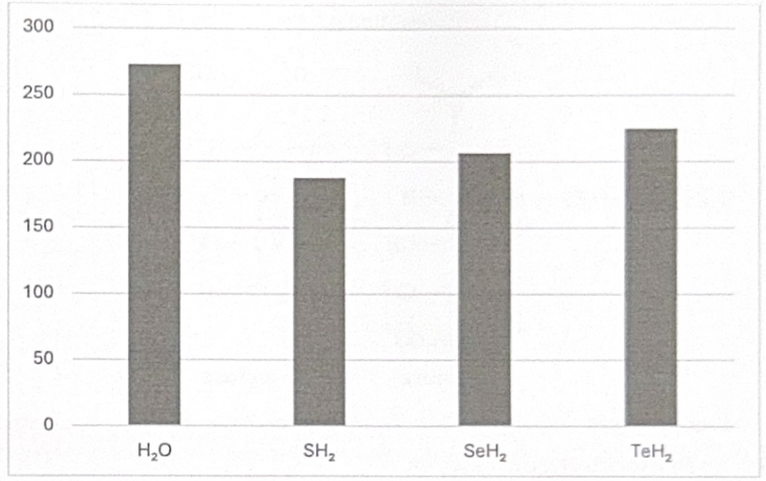


Figure 3.2

(i) Explain the trend in the boiling points of the Group 16 hydrides shown in Fig. 3.2.

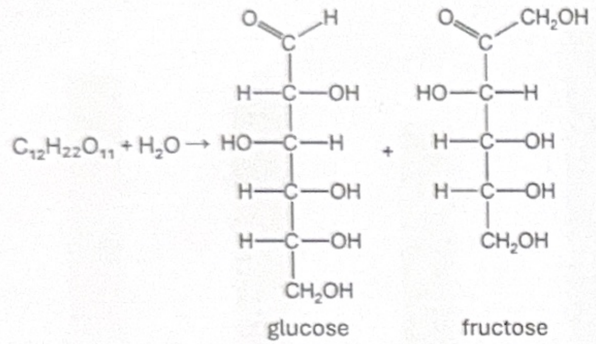
H_2O have ~~high~~ ~~or~~ highest boiling point because it contains hydrogen bond. The rest is increasing because as it go down the group, there are more electrons that created more intermolecular forces (dispersion force).

[2]

[Total: 7]

4 Sucrose, $C_{12}H_{22}O_{11}$, reacts with water to form glucose and fructose in reaction **A**.

reaction **A**



(a) Suggest a name for this type of reaction.

~~Hyd~~ Hydrolysis ~~Hydrogenation~~

[1]

(b) Explain why glucose and fructose are a pair of structural isomers. Your answer should refer specifically to these two molecules.

Both molecules have same number of carbon, oxygen and hydrogen in it, therefore the difference in in it's structure and is called structural isomers. Same molecular formula but different structure.

[2]

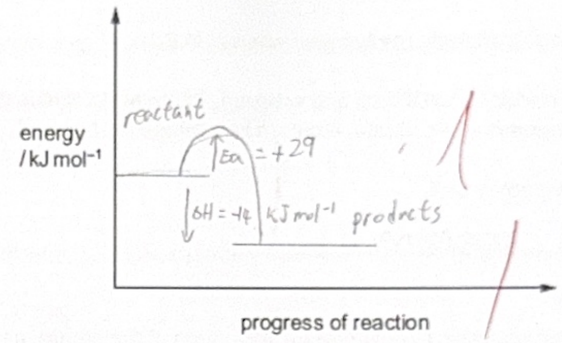
(c) Reaction **A** occurs faster in the presence of an enzyme. This is reaction **B**.

(i) Estimate values for the activation energy for reaction **A** and the enthalpy change for reaction **B**.

	activation energy /kJ mol^{-1}	enthalpy change /kJ mol^{-1}
reaction A	+60	-14
reaction B	+29	-14

[2]

(ii) Sketch a labelled energy level diagram for reaction **B**. Use relevant values from **(c)**(i).



[2]

(d) 1.00g of glucose, $C_6H_{12}O_6$, is completely combusted. The heat energy produced is used to increase the temperature of 250 g of water inside a calorimeter from 25.0 °C to 32.8 °C.

These data can be used to calculate the enthalpy change of combustion of glucose.

(i) Explain what is meant by the term enthalpy change of combustion of glucose.

It is the energy change or enthalpy change when one mole of ~~substance~~ glucose is burnt in excess oxygen under complete combustion and standard condition.

[2]

(ii) Calculate the enthalpy change, in kJ mol^{-1}, for the combustion of glucose.

Assume that all of the heat energy produced is transferred to the water.

Show your working.

$12\times6+12+6\times16 = 180$

$\frac{1}{180} = \frac{1}{180}$ mol

$Q = mc\Delta T$ $\quad \Delta T = 32.8 - 25 = 7.8°$

$250\times10^{-3} \times 4.18 \times 7.8 = 8.151$ kJ

$8.151 \div \frac{1}{180} = 1467.18$

$\simeq 1467$ kJ mol^{-1}

1467

enthalpy change of combustion of sucrose = ... kJ mol^{-1}

[3]

(iii) Estimate a value for the enthalpy change of combustion of fructose.

~~1400~~ 1500 kJ mol^{-1}

[1]

[Total: 13]

5 An unlabelled bottle contains a straight-chain halogenoalkane, **P**. The molecular formula of **P** is C_4H_9X, where **X** is a halogen; bromine, chlorine or iodine.

(a) A test is carried out to identify the halogen present in **P**.

A sample of **P** is added to NaOH(aq) and warmed. Dilute nitric acid is then added followed by a few drops of aqueous silver nitrate. A cream precipitate is observed.

(i) Suggest the identity of **X**.

Br , bromine

[1]

(ii) Write an ionic equation to describe the formation of the cream precipitate. Include state symbols.

$Br^-_{(aq)} + Ag^+_{(aq)} \rightarrow AgBr_{(s)}$

[1]

(iii) Describe a further test which would confirm the identity of **X**.

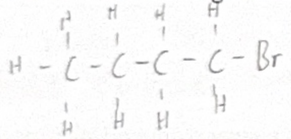
test

expected result

[2]

(b) The reaction of **P** with NaOH(aq) tends to proceed via an S_N2 mechanism.

(ii) Suggest the structure of the straight-chain halogenoalkane **P**.



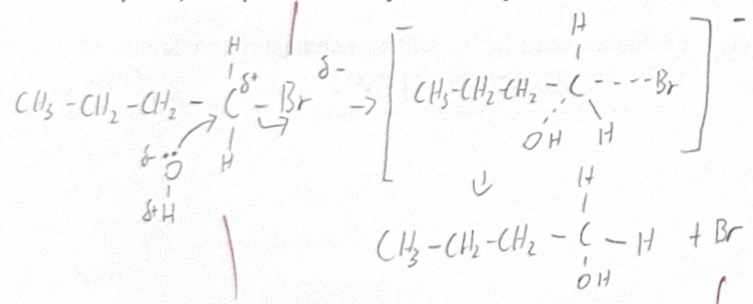
[1]

(iii) Explain why the reaction tends to proceed via an S_N2 mechanism rather than an S_N1 mechanism.

The reaction depends on both reactants's concentration.
The reaction is a straight chain therefore the carbon Br
connects to ~~not~~ only connect with one or two other carbon
that will cause SN_2 to occure.

[2]

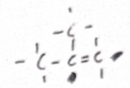
(iv) Draw a labelled mechanism of the reaction between P and hydroxide ions. Include all relevant dipoles, lone pairs and curly arrows in your answer.



[3]

(c) Two different halogenoalkanes, **Q** and **R**, both with the molecular formula C_4H_9Cl, are separately dissolved in ethanol and heated under reflux with sodium hydroxide.

The major organic product of each of these reactions is methylpropene.



(i) Name the type of reaction occurring.

elimination

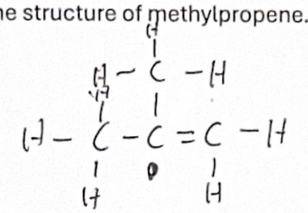
[1]

(ii) Write an equation, using molecular formulae, to represent the reaction occurring.

$C_4H_9Cl_{(in\ ethanol)} + NaOH_{(ethanol)(aq)} \rightarrow C_4H_8 + H_2O + NaCl$

[1]

(iii) Draw the structure of methylpropene.



[1]

(iv) Give the names of P and R.

2- methyl, 2-Chloro propane.

[2]

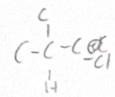
(d) There is a structural isomer, **S**, of C_4H_9Cl which displays optical isomerism.

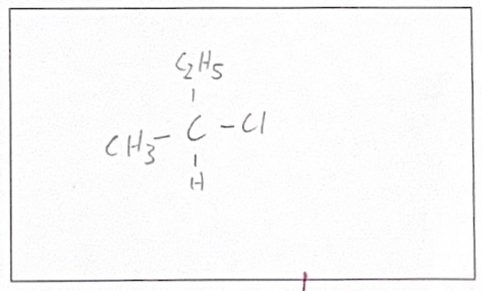
(i) Explain what is meant by optical isomerism.

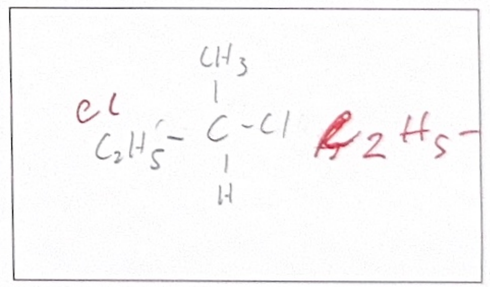
There are one ~~carbon~~ element connecting to four different element

[1]

(ii) Draw the two optical iosmers of **S**.







[2]

[Total: 18]