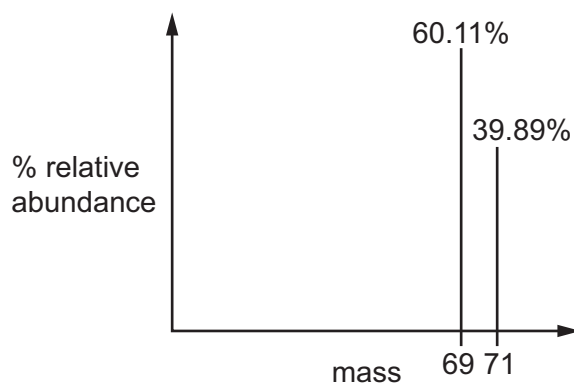


Answer **all** the questions in the spaces provided.

- 1 Gallium is an element in Group 13.

A sample of gallium is analysed using a mass spectrometer. The mass spectrum produced is shown.



- (a) Explain what is meant by the term *relative atomic mass*.

.....
 [2]

- (b) Calculate the relative atomic mass of gallium in this sample. Give your answer to 4 significant figures.

Show your working.

relative atomic mass = [2]

- (c) Complete the table which describes a gaseous atom of gallium.

isotope	nucleon number	total number of electrons in lowest energy level	type of orbital which contains the electron in the highest energy level
^{71}Ga			

- (d) When gallium is heated in excess chlorine, gallium trichloride, GaCl_3 , is made.

Draw the shape of the gallium trichloride molecule and suggest the Cl-Ga-Cl bond angle.

shape of molecule

bond angle

[2]

- (e) Gallium oxide, Ga_2O_3 , and aluminium oxide react in the same way with $\text{HCl}(\text{aq})$ and with $\text{NaOH}(\text{aq})$.

- (i) Suggest the equation for the reaction between Ga_2O_3 and $\text{HCl}(\text{aq})$.

..... [1]

- (ii) Suggest an equation for the reaction between gallium oxide and $\text{NaOH}(\text{aq})$.

..... [2]

[Total: 12]

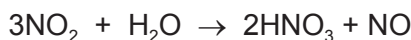
2 Nitric acid can be made in a 3-stage process.

Stage 1 Ammonia is oxidised by oxygen from the air, to form nitrogen monoxide and water. This reaction is carried out at 10–13 atmospheres pressure and 900 °C in the presence of a platinum catalyst.

Stage 2 Nitrogen monoxide reacts with more oxygen to form nitrogen dioxide.



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



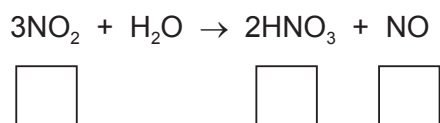
(a) Write an equation to show the reaction occurring in stage 1.

..... [1]

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

[1]

(c) (i) In the boxes, give the oxidation numbers of nitrogen in the nitrogen-containing species for the reaction in stage 3.



[2]

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

.....

.....

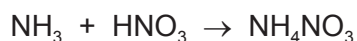
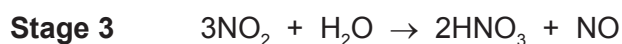
..... [2]

- (d) The release of nitrogen monoxide into the atmosphere causes atmospheric pollution.

State and explain the effect of nitrogen monoxide gas in contact with moist air.

.....
 [2]

- (e) The nitric acid made in stage 3 can then be reacted with ammonia to form ammonium nitrate.



Calculate the volume of nitrogen dioxide, measured at room temperature and pressure, required to make 40 tonnes of ammonium nitrate.

[1 tonne = 1000 kg]

Show your working.

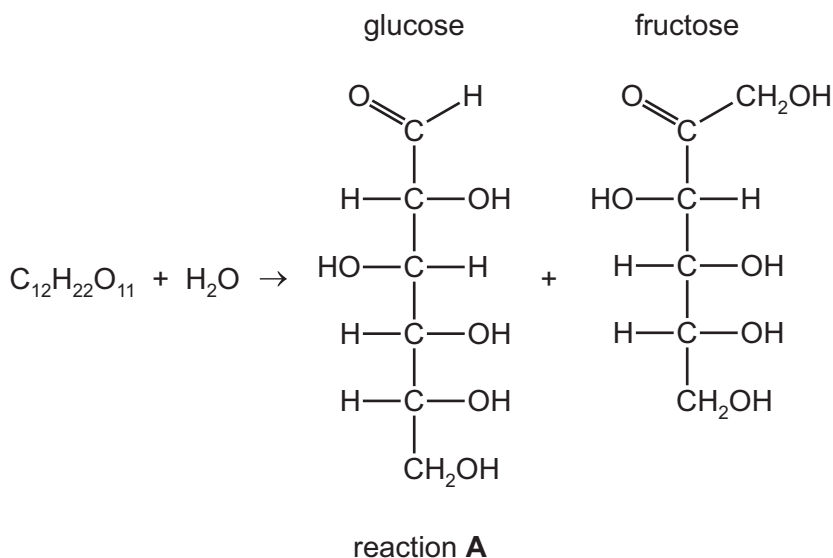
volume of nitrogen dioxide = [3]

- (f) State **one** use of ammonium nitrate.

..... [1]

[Total: 12]

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



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

..... [1]

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

.....

.....

..... [2]

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

- (i) The activation energy for reaction **B** is $+29 \text{ kJ mol}^{-1}$.

Predict a value for the activation energy of reaction **A**.

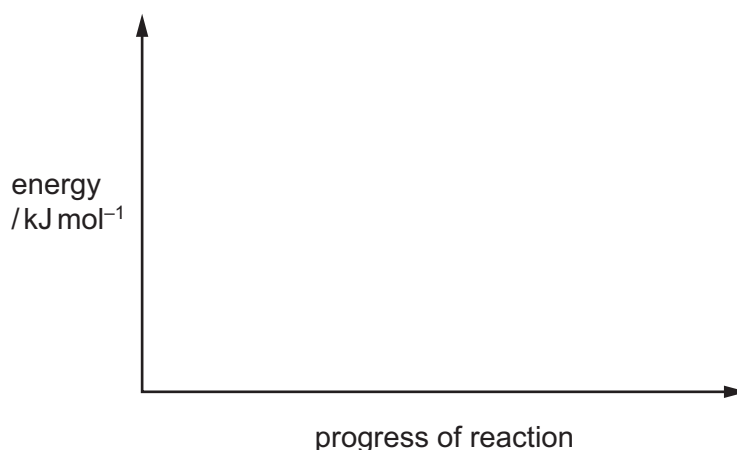
..... [1]

- (ii) The enthalpy change for reaction **A** is -14 kJ mol^{-1} .

Predict a value for the enthalpy change for reaction **B**.

..... [1]

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



[2]

- (d) 1.00 g of sucrose, C₁₂H₂₂O₁₁, 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 40.7 °C.

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

- (i) Explain what is meant by the term *enthalpy change of combustion of sucrose*.

.....

.....

..... [2]

- (ii) Use the *Data Booklet* to calculate the enthalpy change, in kJ mol⁻¹, for the combustion of sucrose.

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

Show your working.

enthalpy change of combustion of sucrose = kJ mol⁻¹

[3]



- 4 (a) An unlabelled bottle contains a straight-chain halogenoalkane, **Q**. The molecular formula of **Q** is $C_5H_{11}X$, where **X** is a halogen; bromine, chlorine or iodine.

A test is carried out to identify the halogen present in **Q**.

A sample of **Q** 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**.

..... [1]

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

..... [1]

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

test

expected result

[2]

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

- (i) Suggest the structural formula of the straight-chain halogenoalkane **Q**.

[1]

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

.....

.....

..... [2]

- (c) Two different halogenoalkanes, **P** 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.

..... [1]

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

..... [1]

- (iii) Draw the skeletal formula of methylpropene.

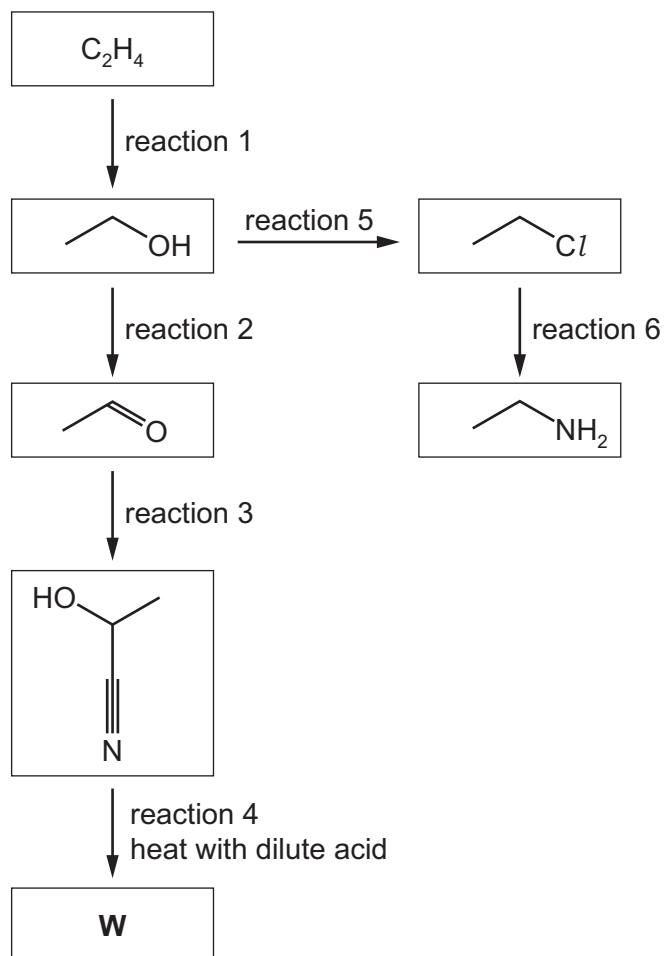
[1]

- (iv) Give the names of **P** and **R**.

..... [2]

[Total: 12]

5 The reaction sequence shows how ethene, C_2H_4 , can be converted into other organic molecules.



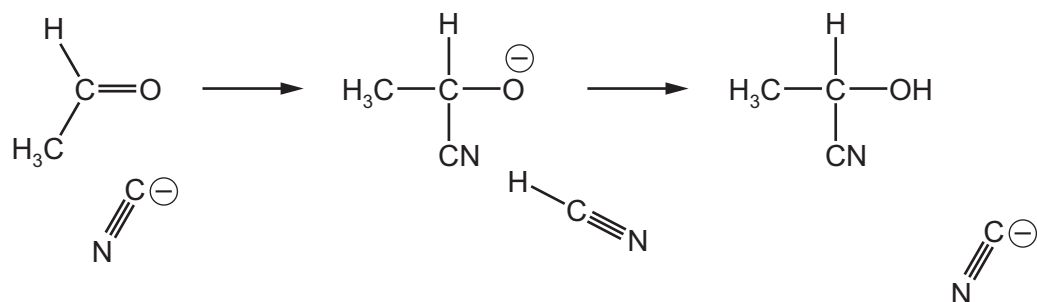
(a) Complete the table to give

- the name of the reaction mechanisms of reactions 1 and 6
- the reagents and conditions required for reactions 1, 2 and 6.

reaction	name of mechanism	name of reagents and conditions
1		
2		
6		

(b) In reaction 3 the organic molecule reacts with HCN and a KCN catalyst.

- (i) Complete the diagram to show the mechanism of the reaction occurring. Include all relevant dipoles, lone pairs and curly arrows in your answer.



[3]

- (ii) Name the functional groups present in the product of reaction 3.

..... [2]

(c) Draw the structure of the organic molecule **W** formed in reaction 4.

[1]

[Total: 12]

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