1 This question is about Group I and Group VII elements.

(a) Give the symbol of the element from Group I or Group VII which has:

(i) atoms with 11 protons atomic # = 11p

Na ..... [1]

(ii) atoms with 35 electrons atomic # = proton # = 35 e^-

Br ..... [1]

(iii) molecules with an M_r of 254. I_2 $127 \times 2 = 254$

I / I_2 ..... [1]

(b) Give the symbol of the element from Group I or Group VII which:

(i) is used to detect unsaturated hydrocarbon molecules

Br_2 ..... [1]

(ii) gives a lilac flame test

K^+ ..... [1]

(iii) can displace aqueous bromide ions.

Cl_2 ..... [1]

[Total: 6]

2 Bonding is the attraction between particles. The particles can be atoms, molecules, ions or electrons.

(a) Bonding can be strong or weak.

(i) Complete Table 2.1 to describe the **strong** bonding in the substances shown.

Table 2.1

	sodium chloride	**bromine**	**magnesium**	**silicon(IV) oxide**
type of strong bonding	ionic	covalent	metallic	covalent
symbol of particle attracted	Na^+ and Cl^-	Br	Mg^{2+} and e^-	Si and O
type of particle attracted	ions	atoms	ions and electrons	atoms

[7]

(ii) Name the **weak** attractions that are overcome when bromine boils.

intermolecular force [1]

(b) Sodium chloride and silicon(IV) oxide both have a lattice structure.

(i) Describe the arrangement of ions in sodium chloride.

Strong attraction force between Na^+ and Cl^-

Regular arrangent [2]

(ii) Name a substance that has a giant covalent lattice and similar properties to silicon(IV) oxide.

Diamond [1]

[Total: 11]

3 The salt zinc sulfate is prepared by adding excess solid zinc carbonate to dilute sulfuric acid.

(a) Complete the equation for this reaction.

$$ZnCO_3 + H_2SO_4 \rightarrow ZnSO_4 + \text{CO}_2 + \text{H}_2\text{O}$$ [1]

(b) Name **one** other zinc compound that reacts with dilute sulfuric acid to produce zinc sulfate.

Zinc oxide [1]

(c) The reaction is complete when no more zinc carbonate dissolves and a white solid of excess zinc carbonate is seen in the reaction mixture.

State **one** other observation which shows the reaction is complete.

No more bubbles [1]

(d) 200 cm^3 of solution **A** contains 30 g of dissolved $ZnSO_4$.

The maximum concentration of $ZnSO_4$ at room temperature is 60 g in 100 cm^3 of water.

(i) State the term used to describe a solution containing the maximum concentration of solute.

saturated solution [1]

(ii) Water is allowed to evaporate from solution **A**.

Determine the volume of solution **A** when $ZnSO_4$ crystals first appear.

$30g \div \frac{60g}{100cm^3} = 50\ cm^3$

volume = 50 cm^3 [1]

(iii) Solution **B** is formed when solution **A** is evaporated until 20 cm^3 remains.

Calculate the mass of $ZnSO_4$ that is formed from solution **B**.

$20cm^3 \times 60g/100cm^3 = 12g$

$30g - 12g = 18g$

mass = 18 g [1]

(e) Lead(II) sulfate, $PbSO_4$, is an insoluble salt which forms when an aqueous lead(II) salt reacts with an aqueous sulfate salt.

(i) Name a lead(II) salt and a sulfate salt that will form lead(II) sulfate.

lead(II) salt ..... lead (II) nitrate .....

sulfate salt ..... sodium sulfate .....

[2]

(ii) Name this technique of insoluble salt preparation.

..... precipitation method ..... [1]

(iii) Describe how pure lead(II) sulfate can be obtained from the reaction mixture.

..... filter the ppt of lead (II) sulfate .....

..... Wash with distilled water .....

..... Dry in the oven ..... [3]

(iv) Write the ionic equation for this reaction. Include state symbols.

..... $Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$ ..... [2]

(v) Name another insoluble sulfate salt that can be prepared by this method.

..... Barium sulfate ..... [1]

[Total: 15]

4 Chromium, copper and nickel are transition elements.

(a) State **two** physical properties of transition elements that are different from Group I metals.

1 hard

2 high m.p and b.p.
high density [2]

(b) Write the formulas of the following compounds of transition elements.

copper(I) oxide Cu_2O

nickel(II) nitrate $Ni(NO_3)_2$ [2]

(c) Two ions that contain chromium are chromate(VI) ions, CrO_4^{2-}, and dichromate(VI) ions, $Cr_2O_7^{2-}$.

$H^+(aq)$ ions convert $CrO_4^{2-}(aq)$ ions to $Cr_2O_7^{2-}(aq)$ ions. An equilibrium is reached.

$$2H^+(aq) + 2CrO_4^{2-}(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

chromate(VI) dichromate(VI)

(i) Explain why this is **not** a redox reaction.

No change of oxidation number / no gain or lose electrons [1]

(ii) Describe this equilibrium in terms of:

- the rate of the forward reaction and the rate of the reverse reaction

equal

- the concentration of the reactants and of the products.

keep constant [2]

(iii) Explain why increasing the pressure has no effect on the position of equilibrium.

increase pressure change equilibrium when reactant and product are gas [1]

(iv) Explain why adding an alkali moves the position of equilibrium to the left.

Add more OH^- will decrease concentration of H^+, equilibrium shift to left to restore concentration of H^+ [2]

(d) Transition elements form alloys.

(i) Name the alloy which is made by mixing copper with zinc.

Brass ..... [1]

(ii) Mixing chromium and nickel with iron and a non-metallic element makes a type of steel.

Name this type of steel and the non-metallic element used.

type of steel ..... stailess steel .....

non-metallic element ..... carbon .....

[2]

[Total: 13]

5 This question is about compounds of nitrogen.

(a) Ammonia is manufactured by reacting hydrogen with nitrogen in the Haber process.

(i) State **one** source of hydrogen and **one** source of nitrogen.

hydrogen ..... methane / natural gas .....

nitrogen ..... air .....

[2]

(ii) Write the symbol equation for the reaction in the Haber process.

..... $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ ..... [2]

(iii) State the typical pressure, in kPa, used in the Haber process.

..... 20000 ..... kPa [1]

(b) Aqueous ammonia, $NH_3(aq)$, is used to detect aqueous metal ions. The colour of the precipitate formed when $NH_3(aq)$ is added to an aqueous solution indicates the metal ion present.

(i) State the colour and give the name of the precipitate formed when $NH_3(aq)$ is added to $Cr^{3+}(aq)$ ions.

colour of precipitate ..... green .....

name of precipitate ..... chromium (III) hydroxide .....

[2]

(ii) When a few drops of $NH_3(aq)$ are added to $Zn^{2+}(aq)$ a white precipitate forms.

When a few drops of $Zn^{2+}(aq)$ are added to $NH_3(aq)$ no precipitate forms.

Explain these observations.

..... zinc hydroxide is a white precipitate formed .....

..... zinc hydroxide dissolves in excess $NH_3(aq)$ .....

..... [2]

(c) The reaction between ammonia and fluorine forms nitrogen trifluoride, $NF_3(g)$, and hydrogen fluoride, HF(g).

$$NH_3(g) + 3F_2(g) \rightleftharpoons NF_3(g) + 3HF(g) \qquad \Delta H = -870\,kJ/mol$$

(i) State how the equation shows this reaction is:

exothermic ΔH is negative

reversible. ⇌

[2]

(ii) Figure 5.1 shows an incomplete reaction profile diagram for the forward reaction.

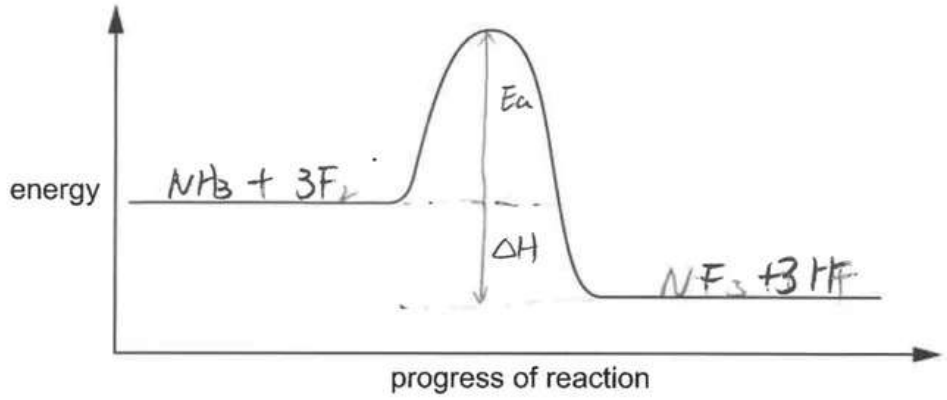


Figure 5.1

On Figure 5.1:

- write the formulas of the reactants and the products
- draw an arrow, labelled E_a, to show the activation energy
- draw an arrow, labelled ΔH, to show the enthalpy change.

[3]

(iii) The equation for the forward reaction can be represented as shown.

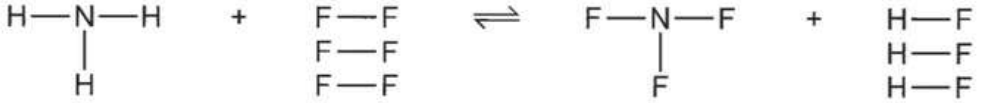


Table 5.1

bond	N–H ×3	F–F ×3	N–F ×3
bond energy in kJ/mol	390	150	270

Use the bond energies in Table 5.1 and the ΔH value of –870 kJ/mol for the forward reaction to calculate the H–F bond energy. Use the following steps.

- Calculate the energy needed to break the bonds in the reactants.

  $3 \times 390 + 150 \times 3 = 1620$ kJ

  1620 ..... kJ

- Calculate the total energy released when the bonds in the products form.

  $1620 - E_{new} = -870$

  $E_{new} = 2490$ kJ

  2490 ..... kJ

- Calculate the bond energy of the H–F bond.

  $3 \times 270 + E(H\text{-}F) \times 3 = 2490$

  $E(H\text{-}F) = 560$

  560 ..... kJ/mol

[4]

(d) On Figure 5.2, complete the dot-and-cross diagram of a molecule of nitrogen trifluoride.

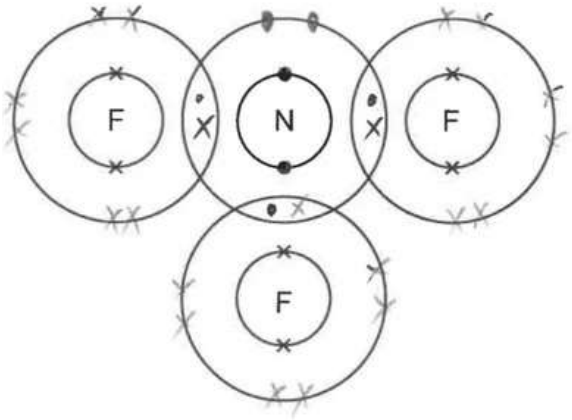


Figure 5.2

[3]

[Total: 21]

6 Alcohols are a homologous series of organic compounds.

Table 6.1 gives some information about alcohols **A**, **B**, **C** and **D**.

Table 6.1

alcohol	A	B	C	D
number of carbon atoms	1	2	3	3
name	methanol	ethanol		
structural formula	CH_3OH	CH_3CH_2OH	$CH_3CH_2CH_2OH$	$CH_3CH(OH)CH_3$

(a) State why the homologous series of alcohols have similar chemical properties.

have same functional group ..... [1]

(b) Use information from Table 6.1 to answer the following questions.

(i) Deduce the number of electrons in a molecule of **A**.

18 ..... [1]

(ii) State the molecular formula of **B**.

C_2H_6O ..... [1]

(iii) Name **C**.

propan-1-ol ..... [1]

(iv) Name **D**.

propan-2-ol ..... [1]

(c) The structural formula of **B**, CH_3CH_2OH, can also be written as C_2H_5OH.

Explain why the structural formula C_3H_7OH does **not** identify **C**.

C has isomers ..... [1]

(d) Ethanol is a fuel.

Write the symbol equation for the complete combustion of ethanol.

$CH_3CH_2OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ ..... [2]

(e) Ethanol can be oxidised by two methods.

method 1 Heating ethanol with an acidified aqueous oxidising agent.

method 2 The oxidation of ethanol using bacteria.

(i) Name the acidified aqueous oxidising agent used in **method 1**.

Potassium manganate (VII) [1]

(ii) Give the chemical name of the organic product in **method 1**.

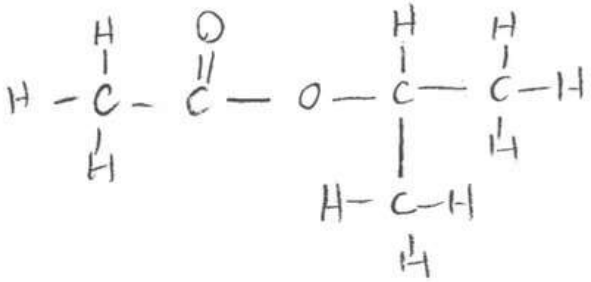
ethanoic acid [1]

(iii) Name the food product in **method 2**.

vinegar [1]

(f) Alcohol **D** reacts with ethanoic acid in the presence of a catalyst to form ester **X** and one other product.

(i) Draw the displayed formula of ester **X**.



[2]

(ii) Name the other product formed.

water [1]

[Total: 14]