Marks

- Balance the following equation: **2**

$$Fe_2O_3(s) + CO(g) \rightarrow Fe(s) + CO_2(g)$$

$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$

- Calculate the mass of sodium hydroxide required to make 500 mL of a 0.200 M aqueous solution. **6**

The number of moles in a solution is given by

number of moles = concentration (in M) × volume (in L)

The solution contains 0.2 × 500/1000 = 0.1 moles of NaOH.

The molar mass of NaOH is 22.99 (Na) + 16.00 (O) + 1.01 = 40.00 g mol^{-1}.

The mass of NaOH required is 0.1 × 40.00 = 4.00 g

Answer: **4.00 g**

What volume of the above solution would be required to neutralise 50.0 mL of 0.100 M hydrochloric acid solution?

The neutralization is a 1:1 reaction:

$HCl + NaOH \rightarrow NaCl + H_2O$

50.0 mL of 0.1000 HCl contains 0.1 × 50/1000 = 0.005 moles

The volume is given by

volume (in L) = number of moles (in mol) / concentration

The volume of the 0.200 M NaOH containing 0.005 moles is therefore:

volume = 0.005 / 0.200 = 0.025 L or 25 mL

Answer: **25.0 mL**

Marks 4

- Aluminium acts as a reducing agent in the thermite reaction where Fe_2O_3 is reduced to metallic iron. Write a balanced equation for the thermite reaction.

$2Al(s) + Fe_2O_3(s) \rightarrow Al_2O_3(s) + 2Fe(s)$

What is the maximum theoretical mass of Fe that can be produced when 270 g of Al reacts with excess Fe_2O_3 in the thermite reaction?

The number of moles of aluminium is given by

number of moles = mass (in g) / atomic mass

The atomic mass of Al is 26.98 g mol^{-1} so 270 g corresponds to 270 / 26.98 = 10.0 mol.

The chemical equation shows that two moles of Al produce two moles of Fe (or 1 mole produces 1 mole). The maximum yield of Fe is there 10.0 mol.

The mass of iron is given by

mass (in g) = number of moles × atomic mass

The atomic mass of Fe is 55.85 g mol^{-1} so 10 mol of iron corresponds to

mass of iron = 10.0 × 55.85 = 560 g

Answer: **560 g**

- Give the formula and name of a binary ionic compound formed from the following elements.

Marks 6

	Formula	Name
magnesium and oxygen	**MgO**	**magnesium oxide**
barium and bromine	**$BaBr_2$**	**barium bromide**
sodium and nitrogen	**Na_3N**	**sodium nitride**
potassium and oxygen	**K_2O**	**potassium oxide**

- Explain why some ionic compounds are soluble in water and usually insoluble in hydrocarbon solvents such as kerosene.

2

When an ionic solid dissolves, the strong ionic bonds between the constituent ions need to be broken (lattice enthalpy). In water, strong bonds are formed between the ions and the highly polar water molecules to give aquated ionic species. The energy released in this process (enthalpy of solvation) is sufficient to overcome the lattice enthalpy and the solid dissolves. In kerosene, there is little attraction between the ions and the non-polar solvent. The solvation enthalpy is very small in this case, certainly not large enough to overcome the lattice enthalpy, and so dissolution does not occur.

- The relative atomic mass of magnesium is reported as 24.3. Show how this figure is calculated given the natural abundances of the following isotopes of magnesium: ^{24}Mg (79.0 %); ^{25}Mg (10.0 %); ^{26}Mg (11.0 %). **Marks 2**

The relative atomic mass of magnesium is the weighted average of the masses of its isotopes:

$$\left(24\times\frac{79.0}{100}\right)+\left(25\times\frac{10.0}{100}\right)+\left(26\times\frac{11.0}{100}\right)=24.3\,\text{g mol}^{-1}$$

- With examples, briefly explain what allotropes are. **2**

Allotropes are different structural arrangements of the same atoms of an element.

Carbon occurs naturally as either graphite, which consists of sheets of planar hexagonal rings, and diamond, a three dimensional structure with tetrahedrally coordinated carbon. carbon. Oxygen exists as either the gaseous diatomic O_2 molecule or the gaseous triatomic O_3 (ozone).

- Complete the following table. **2**

Formula	Name
Na_2CO_3	**sodium carbonate**
Fe_2O_3	iron(III) oxide
PCl_3	**phosphorus trichloride**
NH_3	ammonia