2. Atoms, molecules and stoichiometry

2.4 Reacting masses and volumes

Paper 2

Question Paper

1 **(b)** Carbon is found in inorganic compounds such as carbonates.

(i) Write an equation for the reaction of magnesium carbonate with dilute HCl(aq).

..... [1]

2 Ethanedioic acid, HO_2CCO_2H, has a relative molecular mass of 90.0.

(a) (iii) Calculate how many atoms of carbon are present in 0.18 g of ethanedioic acid, HO_2CCO_2H.

Show your working.

atoms of carbon present = ... [3]

3 Sulfides are compounds that contain sulfur but not oxygen.

(d) The compound As_2S_3 is a common mineral.

When As_2S_3 is heated strongly in air, it forms a mixture of products, as shown.

$$2As_2S_3(s) + 9O_2(g) \rightarrow As_4O_6(s) + 6SO_2(g)$$

(i) A sample containing 0.198 g As_2S_3 is placed in 0.100 dm^3 of pure oxygen, an excess, in a reaction chamber connected to a gas syringe at room temperature.

The reactants are heated until no further change is observed. The products are then allowed to cool to room temperature.

Calculate the volume, in dm^3, of gas present at the end of the experiment.

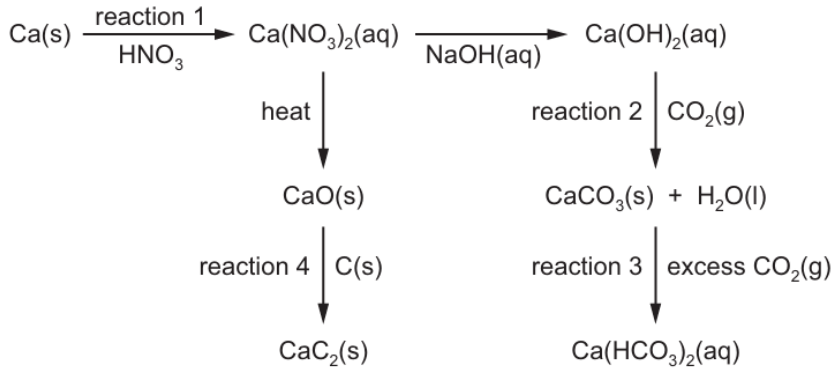
The molar volume of gas is 24.0 $dm^3\,mol^{-1}$ under these conditions. Assume that the pressure is constant throughout the experiment.

Show your working.

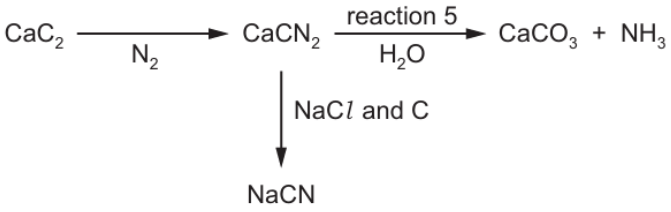
volume of gas remaining = ... dm^3

[4]

4 The reaction scheme shows some reactions of calcium.



(d) The flowchart shows some reactions of CaC_2.



(i) Reaction 5 can be used to prepare NH_3.

$$CaCN_2 + 3H_2O \rightarrow CaCO_3 + 2NH_3$$

Calculate the minimum mass, in tonnes, of calcium cyanamide, $CaCN_2$, that is required to produce 1.50×10^6 tonnes of NH_3.

Show your working.

1 tonne = 1.00×10^6 g

minimum mass of $CaCN_2$ = ... tonnes

[2]

5 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.

$$2NO + O_2 \rightleftharpoons 2NO_2 \qquad \Delta H = -114\,kJ\,mol^{-1}$$

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

$$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$$

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

Stage 3 $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

$$NH_3 + HNO_3 \rightarrow NH_4NO_3$$

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]

6 There are many different types of aliphatic and aromatic hydrocarbons.

(c) The equation for the complete combustion of ethene is shown.

$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$$

Calculate the volume, in dm^3, of carbon dioxide formed in the complete combustion of 1.00 g of ethene at room temperature and pressure.

volume of CO_2 = ... dm^3 [3]