1.2 Reacting Masses & Volumes

Question Paper

Course	DP IB Chemistry
Section	1. Stoichiometric Relationships
Topic	1.2 Reacting Masses & Volumes
Difficulty	Medium

Time allowed: 50

Score: /41

Percentage: /100

Question 1a

a) Astronauts on the Apollo 13 Mission in 1970 avoided disaster by making use of lithium hydroxide canisters, to absorb waste carbon dioxide in their spacecraft through a chemical reaction. The reaction produces lithium carbonate and water as the only products.

i) Write a balanced equation for the reaction between lithium hydroxide and carbon dioxide.

ii) Determine the mass, in kg, of carbon dioxide absorbed by 4.00 kg of lithium hydroxide.

[4 marks]

Question 1b

b) Calculate the percentage yield of lithium carbonate if 5.00 g of lithium hydroxide produces 6.76 g of lithium carbonate.

[2 marks]

Question 1c

c) Determine the maximum volume, in dm^3, of carbon dioxide at 293 K and 100 kPa that can be absorbed by 125.0 g of lithium hydroxide.

[2 marks]

Question 1d

d) When the astronauts on Apollo 13 were solving the problem of excess carbon dioxide in their spacecraft, they had to be careful with their calculations of the volumes of ideal gases.

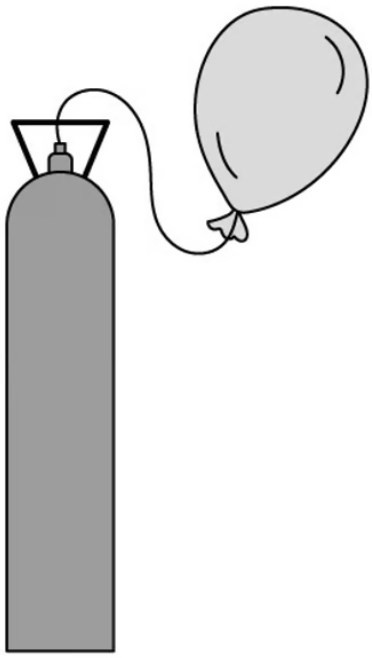
Explain what is meant by the term *ideal gas* and state the conditions under which carbon dioxide shows deviation from ideal gas behaviour.

[2 marks]

Question 2a

a) Gas cylinders of helium, like the one shown below, are sometimes used to inflate party balloons.

Figure 1



A typical 11-inch party balloon has a fully inflated volume of 14.1 dm^3. The pressure in the gas cylinders is 20,000 kPa. If the gas cylinder can fill 160 balloons at 298 K and 108 kPa, what is the total volume of helium inside the gas cylinder in dm^3?

[1 mark]

Question 2b

b) Sketch a graph to show the relationship between the volume and temperature of an ideal gas at constant pressure. Describe the relationship between the two variables.

[2 marks]

Question 2c

c) Deep sea divers sometimes breathe mixtures of helium and oxygen in their scuba diving tanks when the conditions are very deep, so they can avoid nitrogen narcosis.

If a bubble of gas escapes from a scuba tank at 60 m depth where the pressure is 588 kPa and the temperature is 8 ^{o}C, determine the increase in the size of the bubble by the time it reaches the surface where the pressure is 100 kPa and the temperature is 20 ^{o}C.

[2 marks]

Question 2d

d) Commercial aircraft are fitted with oxygen cannisters that provide a supply of oxygen in case of the loss of cabin pressure. The cannisters contain sodium chlorate(V) which produces oxygen in the following decomposition reaction.

$$2NaClO_3\,(s) \rightarrow 2NaCl\,(s) + 3O_2\,(g)$$

Determine the mass of sodium chlorate(V) needed to produce 10.0 dm^3 of oxygen at 298 K and 90 kPa.

[4 marks]

Question 3a

a) An analysis of a 2.54 g antacid tablet containing $Mg(OH)_2$ was carried out by titration using 40.00 cm^3 of 1.25 $moldm^{-3}$ sulfuric acid. The acid was in excess.

i) Write an equation for the reaction.

ii) Determine the amount, in mol, of sulfuric acid.

[2 marks]

Question 3b

b) The excess sulfuric acid reacted with 21.45 cm^3 of 1.51 $moldm^{-3}$ NaOH. Determine the amount of excess acid present.

[2 marks]

Question 3c

c) Calculate the amount of sulfuric acid that reacted with the $Mg(OH)_2$.

[1 mark]

Question 3d

d) Determine the mass of $Mg(OH)_2$ that was present in the tablet.

[1 mark]

Question 3e

e) Determine the percentage mass of $Mg(OH)_2$ that was present in the tablet.

[1 mark]

Question 4a

a) Ammonia and nitrogen monoxide react together according to the following equation:

$$4NH_3\,(g) + 6NO\,(g) \rightarrow 5N_2\,(g) + 6H_2O\,(g)$$

50.0 dm^3 of ammonia is reacted with 50.0 dm^3 of nitrogen monoxide at 150.0 ^oC and 100 kPa. Identify the excess reagent and determine the volume of nitrogen produced.

[2 marks]

Question 4b

b) Determine the volume of excess gas and hence total volume of gas after the reaction has finished.

[2 marks]

Question 4c

c) What mass of nitrogen is produced in the reaction? Express your answer to an appropriate number of significant figures.

[3 marks]

Question 4d

d) Explain why calculating the gas volumes in the reaction is likely to be more accurate at 150 °C than at room temperature.

[1 mark]

Question 5a

a) The chlorine level in a swimming pool should lie between 1.0 and 3.0 ppm. Explain the meaning of ppm and express this concentration range in $mol dm^{-3}$.

[2 marks]

Question 5b

b) The amount of dissolved chlorine can be analysed by reacting with excess iodide ions under acidic conditions, and titrating the liberated iodine against standard sodium thiosulfate solution in a two-step process:

$$Cl_2(aq) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(aq)$$

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

A 25.0 mL sample of chlorine water was analysed and the volume of 0.120 $moldm^{-3}$ sodium thiosulfate solution, $Na_2S_2O_3$, needed to react with the iodine was recorded in **Table 1**.

Table 1

Volume of $Na_2S_2O_3$	I	II	III
Initial burette reading / $mL \pm 0.05$	1.05	23.40	2.10
Final burette reading / $mL \pm 0.05$	23.40	45.70	24.50
Titre / mL			

Calculate the mean titre and determine the number of moles of sodium thiosulfate that reacted.

[2 marks]

Question 5c

c) Determine the amount of chlorine, in mol, present in the sample of chlorine water.

[1 mark]

Question 5d

d) Calculate the concentration of the chlorine water in $moldm^{-3}$ and in gdm^{-3}.

[2 marks]