IB · SL · Chemistry

1 hour 9 questions

Structured Questions

Ideal Gases

Ideal Gases / Molar Gas Volume / The Ideal Gas Equation / Real Gases

Easy (3 questions)	/19
Medium (3 questions)	/27
Hard (3 questions)	/27
Total Marks	**/73**

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Easy Questions

1 (a) A sample of pure magnesium nitrate, $Mg(NO_3)_2$, was decomposed by heating as shown in the equation below

$$2Mg(NO_3)_2\,(s) \rightarrow 2MgO\,(s) + 4NO_2\,(g) + O_2\,(g)$$

A 0.75 g sample of $Mg(NO_3)_2$ was completely decomposed by heating.

Calculate the amount, in moles, of magnesium nitrate that was decomposed. Give your answer to 2 decimal places.

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(2 marks)

(b) Calculate the total amount, in moles, of gas produced in the reaction. Give your answer to 2 decimal places.

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(2 marks)

(c) Calculate the total volume, in m^3, of gas produced at 333 K and 100 kPa.

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(2 marks)

2 (a) 90 cm^3 ammonia gas, NH_3 (g), is combusted in oxygen, O_2 (g), to produce nitrogen oxide and water, H_2O (l). What is the total volume of gases remaining when 90 cm^3 of ammonia is combusted completely with 50 cm^3 of oxygen according to the equation shown?

$$4NH_3\,(g) + 5O_2\,(g) \rightarrow 4NO\,(g) + 6H_2O\,(l)$$

Deduce the limiting reagent for the combustion of ammonia, 90 cm^3 ammonia gas, NH_3 (g), is combusted in oxygen.

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(1 mark)

Calculate the total volume, in cm^3, of gases remaining for the reaction in part (a).

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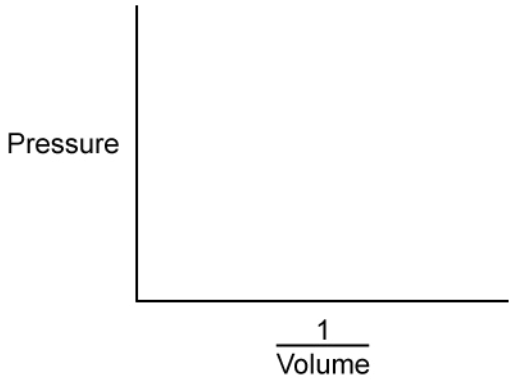
(b) **(4 marks)**

(c) Sketch a line on the graph below that shows the correct relationship between pressure and $\frac{1}{\text{volume}}$



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(1 mark)

(d) At 25 ^{o}C and 100 kPa a gas occupies a volume of 35 dm^3. Using the equation $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$, calculate the new temperature, in ^{o}C, of the gas if the volume is decreased to 15 dm^3 at **constant** pressure.

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(2 marks)

3 (a) Sodium azide, NaN_3, decomposes to form sodium and nitrogen.

Write a balanced symbol equation for this reaction.

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(2 marks)

(b) Under certain conditions, 210 g of sodium azide decomposed.

Calculate the amount, in mol, of sodium azide that decomposed.

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(1 mark)

(c) The nitrogen formed in this reaction fills a volume of 97 000 cm^3 at a pressure of 110 kPa.

Use your answer to part b) and sections 1 and 2 in the Data Booklet to calculate the temperature, in Kelvin, of the nitrogen gas.

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(2 marks)

Medium Questions

1 (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.

[1]

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

[3]

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(4 marks)

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

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(2 marks)

(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.

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(2 marks)

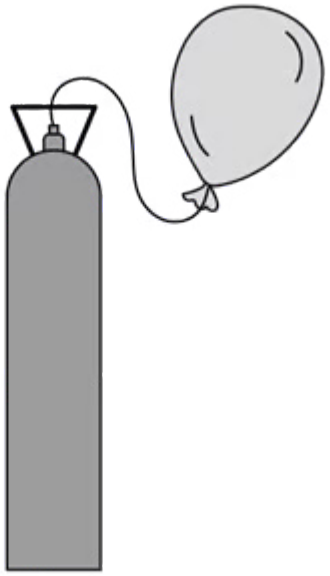
(d) When the astronauts on Apollo 13 were solving the problem of excess carbon dioxide in their spacecraft, they had to be careful with their calculations of the volumes of ideal gases.

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)

2 (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?

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(1 mark)

(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.

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(2 marks)

(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.

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(2 marks)

(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.

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

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

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(4 marks)

3 (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.

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(2 marks)

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

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(2 marks)

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

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(3 marks)

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

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(1 mark)

Hard Questions

1 (a) Phosphine, PH_3, is a gas formed by heating phosphorous acid, H_3PO_3, in the absence of air, as shown in the equation below.

$$4H_3PO_3\,(s) \rightarrow PH_3\,(g) + 3H_3PO_4\,(s)$$

3.45×10^{-2} mol of H_3PO_3 is completely decomposed by this reaction.

State the expected molecular shape and expected bond angle in PH_3 (g).

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(1 mark)

(b) Calculate the volume of phosphine gas formed, in cm^3, at 100 kPa pressure and 210 °C.

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(5 marks)

(c) 1.85 g of white phosphorus was used to make phosphine according to the equation.

$$P_4\,(s) + 3OH^-\,(aq) + 3H_2O\,(l) \rightarrow PH_3\,(g) + 3H_2PO_2^-\,(aq)$$

This phosphorus was reacted with 75.00 cm^3 of 4.50 mol dm^{-3} sodium hydroxide solution. Deduce, showing your working, which was the limiting reagent.

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(3 marks)

(d) Using section 2 of the Data booklet determine the volume of phosphine, measured in cm^3 at standard temperature and pressure, that was produced. Give your answer to 3 significant figures.

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(1 mark)

2 (a) An empty 1.5 dm^3 Tupperware container has been kept in the fridge without a lid at 5 °C. The container is removed from the fridge and allowed to reach a temperature of 21 °C. Using your knowledge of Charles's Law, determine the volume of gas, in cm^3, that escaped from the container.

(4 marks)

(b) A balloon contains 2500 mL of helium gas at a temperature of 75 °C. Determine the new volume in mL of the gas when the temperature changes to 55 °C assuming the pressure is constant. Give your answer to three significant figures.

(2 marks)

(c) A 10.0 L container of helium gas with a pressure of 33 000 Pa at 0 °C is heated until the new pressure is 200 000 Pa. Determine the new temperature of the gas assuming the volume remains constant.

(2 marks)

3 (a) Oxygen exists as a diatomic gas, O_2 (g). A sample of O_2 (g) was made during a chemical reaction. When measured at 303 kPa and 28 °C the sample occupied a volume of 95.0 cm^3.

Calculate the mass of oxygen formed.

(2 marks)

(b) O_2 (g) does not behave as an ideal gas under these conditions.

Explain why O_2 (g) behaves even **less** ideally at:

- very high pressures
- very low temperatures

(2 marks)

(c) The homologous series of alkanes undergo combustion with oxygen.

A 2.0 dm^3 flask contains 10.84 g of a gaseous alkane, **X**. The pressure in the flask is 300 kPa and the temperature is 20 ºC.

Write an equation for the complete combustion of **X**.

(5 marks)