States of Matter

Question Paper 3

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	States of Matter
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 3

Time Allowed: **64 minutes**

Score: **/53**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 The unsaturated hydrocarbon ethyne (acetylene), C_2H_2, is widely used in 'oxy-acetylene torches' for cutting and welding metals. In the torch, ethyne is burned in oxygen to produce a flame with a temperature of 3400 K.

(a) Ethyne is a linear molecule with a triple bond, C≡C, between the two carbon atoms.

Draw a 'dot-and-cross' diagram of an ethyne molecule.

[1]

(b) When used for cutting or welding, ethyne is transported in cylinders which contain the gas under pressure. A typical cylinder has a volume of 76 dm^3 and contains ethyne gas at 1515 kPa pressure at a temperature of 25 °C.

Use the general gas equation, $pV = nRT$, to calculate the amount, in moles, of ethyne in this cylinder.

[2]

(c) In some countries, ethyne is manufactured from calcium carbide, CaC_2, which is produced by heating quicklime and coke together at 2300 K.

$$CaO + 3C \longrightarrow CaC_2 + CO$$

When water is added to the CaC_2, calcium hydroxide, $Ca(OH)_2$, and ethyne, C_2H_2, are produced.

(i) Construct a balanced equation for the formation of ethyne from calcium carbide.

.....

(ii) Use this equation and your answer to part **(b)** to calculate the mass of CaC_2 which will react with an excess of water to produce enough ethyne to fill 100 cylinders of the gas.

[3]

(d) The equation for the complete combustion of ethyne is given below.
Use appropriate bond energy data from the *Data Booklet* to calculate a value for the enthalpy change of combustion of ethyne.

$$C_2H_2(g) + 5/2O_2(g) \longrightarrow 2CO_2(g) + H_2O(g)$$

[3]

(e) The value for the standard enthalpy change of combustion of ethyne is $-1300\,kJ\,mol^{-1}$.

(i) Define the term *standard enthalpy change of combustion*.

.....

.....

.....

(ii) Explain why your answer to **(d)** does not have the same value as the standard enthalpy change of combustion.

.....

.....

[3]

[Total: 12]

2 **(a)** State **two** assumptions of ideal gas behaviour.

(i) .....

.....

(ii) .....

.....[2]

Use of the *Data Booklet* is relevant in (b) and (c).

(b) The ideal gas equation is $pV = nRT$. Explain as fully as you can the meaning of the following terms, and give the units for each to correspond with the value of R given in the *Data Booklet*.

(i) p .....

.....

(ii) V .....

.....

(iii) T .....

.....[6]

(c) **(i)** When an evacuated glass bulb of volume 63.8 cm^3 is filled with a gas at 24 °C and 99.5 kPa, the mass increases by 0.103 g. Deduce whether the gas is ammonia, nitrogen or argon.

(ii) Explain why ammonia is the most likely of these three gases to deviate from ideal gas behaviour.

.....

.....

.....

.....

.....[5]

[Total : 13]

3 This question is about the physical chemistry of gases, with particular emphasis on the inert gas argon. Argon exists in the atmosphere as single atoms.

(a) State **two** of the assumptions of the kinetic theory as applied to an inert gas.

(i) .....

.....

(ii) .....

.....
[2]

(b) How many atoms of argon are present in **one** mole of the gas?

.....[1]

(c) You are to calculate the percentage of the volume occupied by the atoms themselves in one mole of argon at room temperature and pressure.

(i) Use the *Data Booklet* to calculate the volume of one atom of argon.
[volume = $\frac{4}{3}\pi r^3$ $\pi = 3.14$]

(ii) Use your answer to **(c)(i)** to calculate the volume of one mole of argon atoms.

(iii) State the volume occupied by one mole of argon (assume it to behave as an ideal gas) at room temperature and pressure.

.....

(iv) What percentage of this volume is occupied by the atoms themselves?

(v) Explain how your answer to **(c)(iv)** justifies one of your assumptions in **(a)**.

.....

.....
[5]

(d) Argon is used to fill electric light bulbs. These have a fine filament of a metal wire, usually tungsten, which glows white hot from its electrical resistance to the current.

Suggest why argon, rather than air, is used to fill electric light bulbs.

.....

.....

.....

.....[2]

[Total : 10]

4 The Haber process for the manufacture of ammonia, NH_3, was originally devised at the start of the 20th century and was developed into a full-scale industrial process by Carl Bosch in 1913.

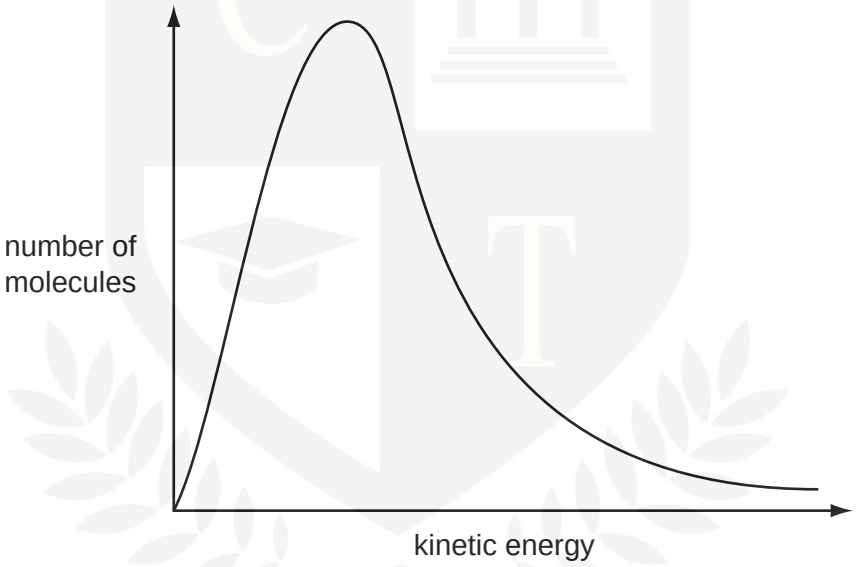
The key step in the process is the reversible reaction of nitrogen and hydrogen in the presence of an iron catalyst.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ\,mol^{-1}$$

(a) The hydrogen for this reaction can be formed by reacting methane with steam, during which carbon monoxide is also produced. Write an equation for this reaction.

..... [1]

(b) Use the Boltzmann distribution shown to explain why a catalyst increases the rate of this reaction.



.....

.....

.....

..... [4]

(c) Draw a three-dimensional diagram to show the shape of an ammonia molecule. Name this shape and state the bond angle.

shape ..... bond angle ..... [3]

(d) The Haber process is typically carried out at a temperature of 400 °C.

(i) With reference to Le Chatelier's Principle and reaction kinetics, state and explain one advantage and one disadvantage of using a higher temperature.

.....

.....

.....

.....

.....

..... [4]

(ii) State the expression for the equilibrium constant, K_p, for the formation of ammonia from nitrogen and hydrogen in the Haber process.

K_p =

[1]

(iii) 2.00 moles of nitrogen and 3.00 moles of hydrogen were put in a vessel and left to reach equilibrium.

At equilibrium, the pressure was 2.00×10^7 Pa and the mixture contained 1.60 moles of ammonia.

Calculate K_p. Include the units.

K_p = ...

units = ...
[5]

[Total: 18]