States of Matter

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	States of Matter
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 1

Time Allowed: **65 minutes**

Score: **/54**

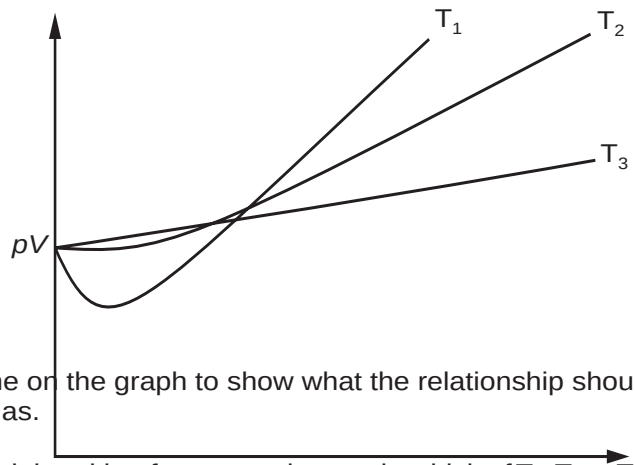
Percentage: **/100**

Grade Boundaries:

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

1 The relationship $pV = nRT$ can be derived from the laws of mechanics by assuming ideal behaviour for gases.

(a) The graph represents the relationship between pV and p for a real gas at three different temperatures, T_1, T_2 and T_3.



(i) Draw **one** line on the graph to show what the relationship should be for the same amount of an **ideal** gas. [1]

(ii) State and explain, with reference to the graph, which of T_1, T_2 or T_3 is the lowest temperature.

.....

..... [1]

(iii) Explain your answer to **(ii)** with reference to intermolecular forces.

.....

..... [1]

(iv) State and explain the effect of pressure on the extent to which a gas deviates from ideal behaviour.

.....

.....

.....

..... [2]

(b) A flask with a volume of 100 cm^3 was first weighed with air filling the flask, and then with another gas, **Y**, filling the flask. The results, measured at 26 °C and 1.00×10^5 Pa, are shown.

Mass of flask containing air = 47.930 g

Mass of flask containing **Y** = 47.989 g

Density of air = 0.00118 g cm^{-3}

Calculate the relative molecular mass, M_r, of **Y**.

(c) Although nitrogen gas makes up about 79% of the atmosphere it does not easily form compounds.

(i) Explain why nitrogen is so unreactive.

M_r of **Y** = ... [4]

.....

..... [1]

(ii) Explain why the conditions in a car engine lead to the production of oxides of nitrogen.

.....

..... [1]

(iii) Give an equation for a reaction involved in the removal of nitrogen monoxide, NO, from a car's exhaust gases, in the catalytic converter.

..... [1]

One of the main reasons for reducing the amounts of oxides of nitrogen in the atmosphere is their contribution to the formation of acid rain.

(iv) Write an equation for the formation of nitric acid from nitrogen dioxide, NO_2, in the atmosphere.

..... [1]

(v) Write equations showing the catalytic role of nitrogen monoxide, NO, in the oxidation of atmospheric sulfur dioxide, SO_2.

.....

..... [2]

[Total: 15]

2 **(a)** State **two** assumptions of the kinetic theory of gases, as applied to ideal gases.

.....

.....

[2]

(b) State the conditions of temperature and pressure under which real gases behave **least** like an ideal gas.

.....

(ii) Explain why real gases do **not** behave ideally under these conditions.

.....

.....

[2]

(c) Gaseous aluminium chloride is dimeric at low temperatures, but the dimer dissociates on heating.

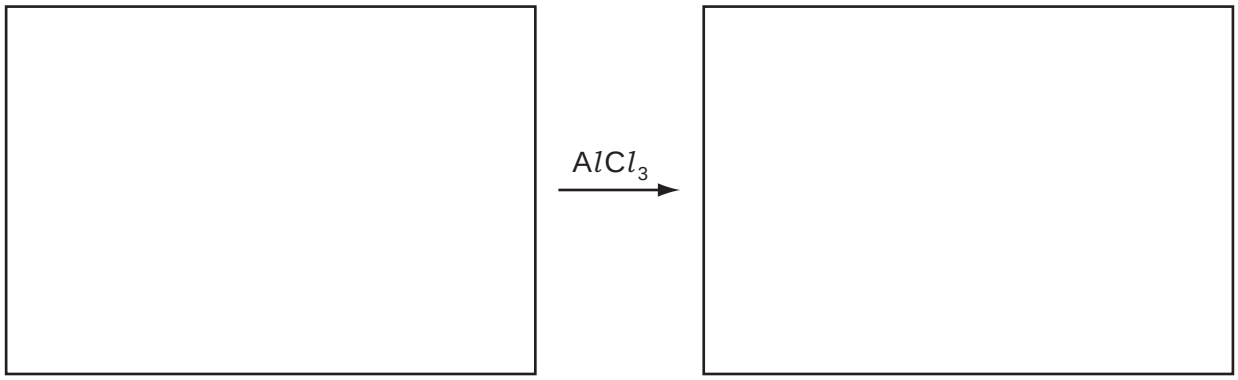
$$Al_2Cl_6(g) \rightleftharpoons 2AlCl_3(g)$$

(i) State whether this dissociation is endothermic or exothermic. Explain your answer.

.....

.....

(ii) Choose **one** reaction in organic chemistry that is catalysed by $AlCl_3$, and write the structural formulae of the reactants and products in the boxes below.



[3]

[Total: 7]

3 Until 1985, carbon was thought to exist in only two structural forms or *allotropes*. In 1985 another form, buckminsterfullerene, was discovered, in which the carbon exists as spherical molecules.

(a) The other two forms of carbon have very different structures.

(i) Name these two forms.

..... and .....

(ii) Give **three** differences in physical properties between these two forms.

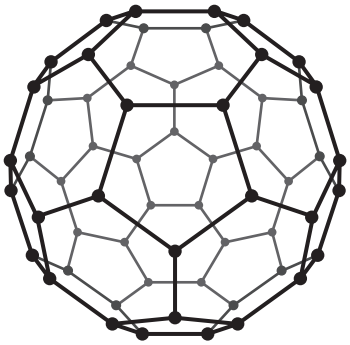
.....

.....

.....

[4]

(b) The diagram shows the structure of buckminsterfullerene.



buckminsterfullerene

The molecule of buckminsterfullerene contains 60 carbon atoms. Suggest a reason why buckminsterfullerene reacts with hydrogen under suitable conditions and give a formula for the product.

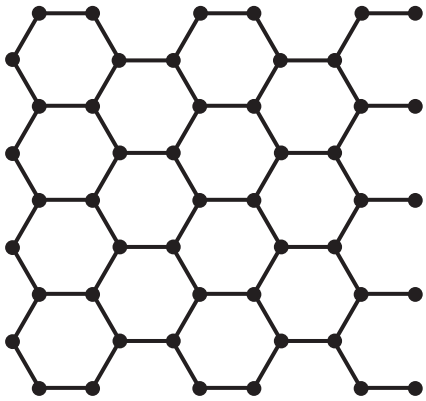
.....

.....

.....

[2]

(c) In 2010, two scientists from the University of Manchester were awarded the Nobel Prize for Physics for their work on graphene, a new structural form of carbon. Graphene is one of the new 'nano-materials' being developed for commercial uses in the next 10 years.



graphene

(i) Graphene is in the form of sheets of carbon one atom thick. Calculate the number of carbon atoms present in a sheet of graphene with a mass of one thousandth of a gram (0.001 g).

The number of hexagons in a large sheet of graphene can be assumed to be one half of the number of carbon atoms. Each hexagon has an area of 690 nm^2.

(ii) Calculate the area of the sheet of graphene in **(i)**.

area of sheet = ... nm^2

(iii) Would you expect samples of graphene and buckminsterfullerene to be electrical conductors? Explain your answers.

graphene .....

.....

buckminsterfullerene .....

.....

[4]

[Total: 10]

4 Some intercontinental jet airliners use kerosene as fuel. The formula of kerosene may be taken as $C_{14}H_{30}$.

(a) To which homologous series of compounds does kerosene belong?

..... [1]

(b) When kerosene burns in an excess of air, carbon dioxide and water form.
Balance the following equation for the complete combustion of kerosene.

$$\text{.....}C_{14}H_{30}(l) + \text{.....}O_2(g) \rightarrow \text{.....}CO_2(g) + \text{.....}H_2O(g)$$ [1]

(c) In this section, give your answers to <u>one</u> decimal place.

The flight path from Beijing to Paris is approximately 8195 km.
A typical intercontinental jet airliner burns 10.8 kg of kerosene for each kilometre covered.

(i) Calculate the mass, in tonnes, of $C_{14}H_{30}$ burnt on a flight from Beijing to Paris.
[1 tonne = 1 000 kg]

(ii) Use your equation in **(b)** to calculate the mass, in tonnes, of CO_2 produced during this flight.

[4]

Bicycles may be carried on commercial airliners. When carried on airliners, bicycles are placed in the luggage hold. This is a part of the aircraft which, in flight, will have different temperatures and air pressures from those at sea level.

This question concerns the change in pressure in an inflated bicycle tyre from when it is at sea level to when it is in the hold of an airliner in flight.

(d) At sea level and a temperature of 20 °C an inflated bicycle tyre contains 710 cm^3 of air at an internal pressure of 6×10^5 Pa.

Use the general gas equation $PV = nRT$ to calculate the amount, in moles, of air in the tyre at sea level.

[2]

The same bicycle, with its tyres inflated at sea level as described in **(d)** above, is placed in the luggage hold of an airliner. At a height of 10 000 m, the temperature in the luggage hold is 5 °C and the air pressure is 2.8×10^4 Pa.

(e) Assuming the volume of the tyre does not change, use your answer to **(d)** to calculate the pressure inside the tyre at a height of 10 000 m.

[2]

[Total: 10]

5 The kinetic theory of gases is used to explain the large scale (macroscopic) properties of gases by considering how individual molecules behave.

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

(i) .....

.....

(ii) .....

.....

[2]

(b) State **two** conditions under which the behaviour of a real gas approaches that of an ideal gas.

(i) .....

(ii) .....

[2]

(c) Place the following gases in decreasing order of ideal behaviour.

ammonia, neon, nitrogen

most ideal ..... **least ideal**

Explain your answer.

.....

.....

[3]

(d) By using the kinetic-molecular model, explain why a liquid eventually becomes a gas as the temperature is increased.

.....

.....

.....

.....[2]

(e) Ethane, CH_3CH_3, and fluoromethane, CH_3F are *iso*-electronic, that is they have the same total number of electrons in their molecules.

Calculate the **total** number of electrons in one molecule of CH_3F.

[1]

(f) The boiling points of these two compounds are given below.

compound	bp/K
CH_3CH_3	184.5
CH_3F	194.7

Suggest explanations for the following.

(i) the close similarity of the boiling points of the two compounds

.....

.....

(ii) the slightly higher boiling point of CH_3F

.....

.....

[2]

[Total: 12]