# States of matter

*(Past Year Topical Questions 2010-2015)*

May/June 2010 (22)

**4** An organic compound, **E**, has the following composition by mass:
C, 48.7%; H, 8.1%; O, 43.2%.

**(a)** Calculate the empirical formula of **E**.

[2]

**(b)** When vaporised in a suitable apparatus, 0.130 g of **E** occupied a volume of 58.0 $cm^3$ at 127 °C and $1.00 \times 10^5$ $N m^{-2}$.

**(i)** Use the expression $pV = \frac{mRT}{M_r}$ to calculate $M_r$ of **E**,

where $m$ is the mass of **E**.

**(ii)** Hence calculate the molecular formula of **E**.

[4]





+6018 – 375 2833

May/June 2011 (21)

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 $6 \times 10^5$ 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 $2.8 \times 10^4$ 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]

May/June 2011 (23)

2 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) ..........................................................................................................

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(ii) ..........................................................................................................

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(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.

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

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**(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]

Oct/Nov 2013 (21)/Q5

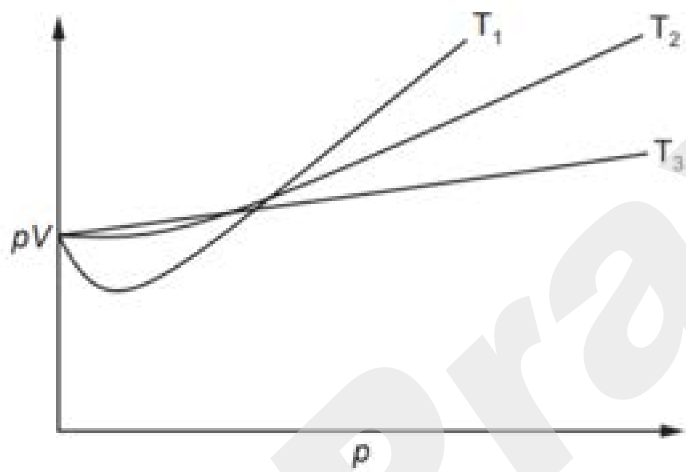
**(d)** A 125 $cm^3$ sample of propane gas, measured at 20 °C and 101 kPa, was completely burnt in air.
The heat produced raised the temperature of 200 g of water by 13.8 °C.
Assume no heat losses occurred during this experiment.

**(i)** Use the equation $pV = nRT$ to calculate the mass of propane used.

May/June 2015 (21)

**2** 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.

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

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

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(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 $1.00 \times 10^5$ 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**.

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





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Oct/Nov 2015 (21)/Q1

At 200 °C and 100 kPa, a 1.36 g sample of this chloride occupied a volume of 200 $cm^3$.

**(iii)** Calculate the relative molecular mass, $M_r$, of the chloride. Give your answer to **three** significant figures.

$M_r$ = .............................. [2]

**(iv)** Deduce the molecular formula of this chloride at 200 °C.

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