Properties of Gases

Question 1 (2016 - Question 4 - Part f)

(*f*) WHAT: there is a **simple (small) whole number ratio of volumes** of reactants and products // **at the same (constant)** conditions of **temperature and pressure** (2 × 3)
[‘*Amounts*’ not acceptable for ‘*volumes*’.]
[‘*At all conditions of temperature and pressure’* and ‘*at s.t.p.*’ are not acceptable.]

Question 2 (2015 - Section B - Question 4 - Part j)

(*j*) CALCULATE: **0.005 (5×10^{-3})** moles (6)

$1.85 \times 10^5 \times 6.50 \times 10^{-5} = n \times 8.3 \times 293$ / $n = \frac{1.85 \times 10^5 \times 6.50 \times 10^{-5}}{8.3 \times 293}$ (3)

= **0.005 (5×10^{-3})** (3)

or

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ * => $\frac{1.85 \times 10^5 \times 6.50 \times 10^{-5}}{293} = \frac{1.01 \times 10^5 \times V_2}{273}$ => $V_2 = \mathbf{1.11 \times 10^{-4}}$ m^3 (3)

$\frac{1.11 \times 10^{-4}}{22.4 \times 10^{-3}}$ = **0.005 (5×10^{-3})** [**Using standard T & P and molar volume at s.t.p.*] (3)

or

$P_1V_1 = P_2V_2$** => $1.85 \times 10^5 \times 6.50 \times 10^{-5} = 1.01 \times 10^5 \times V_2$ => $V_2 = \mathbf{1.19 \times 10^{-4}}$ m^3 (3)

$\frac{1.19 \times 10^{-4}}{24.0 \times 10^{-3}}$ = **0.005 (5×10^{-3})** [***Using room T & P and molar volume at room temperature.*] (3)

[*1 mark deducted if the answer is not correct to one significant figure.*]

Question 3 (2013 - Section B - Question 4 - Part (h))

[illegible]
[Accept formula: H_2SO_4 as conc.]

(h) STATE: **volume varies directly with kelvin (absolute) temperature** / $\frac{V}{T^*} = k$ / $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ /
$V \propto T$ / **gas expands by $^1/_{273}$ of volume at 0 °C for every °C** rise in temp //
for a definite **mass** of gas at **constant pressure** *[*Capital T essential in formulas.]* (2 × 3)

Question 4 (2010 - Section B - Question 4 - Part (h))

(h) WHAT: **A gas that obeys the gas laws (Boyle’s law, kinetic theory, $PV = nRT$) //**
at all values of **temperature and pressure / all conditions / perfectly** (2 × 3)
[Allow “A gas that obeys the assumptions of the kinetic theory” for 6 mark]

Question 5 (2010 - Section B - Question 4 - Part (e))

(e) STATE: **The volumes,** measured at the same temperature and pressure, **of reacting (combining) gases** and their gaseous products **//** **are in (related by)** small (simple) **whole number ratios** (2 × 3)

Question 6 (2009 - Section B - Question 10 - Part (a))

(a) STATE: **equal (same) volumes of gases contain equal (same) numbers of molecules (particles, moles)** (4)
under same conditions* / **at same temperature and pressure** (3)
[Allow (3) for 'the molar volume at s.t.p. is 22.4 litres'.]
*[*Do not accept 'under all conditions' or 'at s.t.p.' or 'at constant temp & pressure']*

GIVE: gases made up of **particles (molecules, atoms) in rapid, random,** straight-line **motion** // **volume of particles (molecules, atoms) zero (negligible) / molecules (particles, atoms) take up no (negligible) space** // **no forces** of attraction or repulsion **between molecules (particles, atoms)** // **collisions** between molecules perfectly **elastic (involve no energy loss)** // **average kinetic energy** of molecules **proportional to kelvin temperature**
ANY TWO: (2 x 3)

DEVIATE: have **intermolecular forces {attractions between particles (molecules, atoms, named correct intermolecular force)** // **molecules (particles, atoms) have volume (take up space, volume not negligible)** // **collisions not** perfectly **elastic** ANY TWO: (2 x 3)

HOW: **1.5** mol (6)

$1.8 \times 10^{24} \div 2 = 9 \times 10^{23}$ molecules (3) $\div 6 \times 10^{23} = 1.5$ moles (3)

Question 7 (2007 - Section B - Question 10 - Part (b))

(b)(i) STATE: **equal (same) volumes of gases contain equal (same) numbers of molecules (particles, moles)** (4)
under same conditions* of temperature and pressure (3)
[* Do not accept "under all conditions".] [Do not accept "at s.t.p."]
[Allow (3) for "the molar volume at s.t.p. is 22.4 litres.]

(ii) WHAT **1.069 – 1.10** m^3 [Accept 1.1 but not greater] (9)

2000 ÷ 44* = 45.4 / 45.5 mol [**addition must be shown for error to be treated as slip.*]	(3)
$V = \frac{nRT}{P} = \frac{45.4/45.5 \times 8.3 \times 290}{1.01 \times 10^5}$ [or other correct form]	(3)
= 1.069 – 1.10	(3)

2000 ÷ 44* = 45.4 / 45.5 mol x 22.4 = 1017 / 1019 litres	(3)

(b)(i) STATE: **equal (same) volumes of gases contain equal (same) numbers of molecules (particles, moles)** (4)
under same conditions* of temperature and pressure (3)
[* Do not accept "under all conditions".] [Do not accept "at s.t.p."]
[Allow (3) for "the molar volume at s.t.p. is 22.4 litres.]

(ii) WHAT **1.069 – 1.10** m^3 [Accept 1.1 but not greater] (9)

$2000 \div 44^* = 45.4 / 45.5$ mol (3)
[**addition must be shown for error to be treated as slip.*]

$$V = \frac{nRT}{P} = \frac{45.4/45.5 \times 8.3 \times 290}{1.01 \times 10^5}$$ [or other correct form] (3)

$= 1.069 – 1.10$ (3)

$2000 \div 44^* = 45.4 / 45.5$ mol $\times 22.4 = 1017 / 1019$ litres (3)
[**addition must be shown for error to be treated as slip.*]

$$V = \frac{1.01325/1.013/1.01/1.0 \times 10^5 \times 1017/1019 \times 290}{1.01 \times 10^5 \times 273}$$ (3)
[or other correct form]
= 1069 – 1100 litres ($1.069 – 1.10\ m^3$) (3)

WHAT: **0.182** kg / **182** g [or answers rounding off to these figures] (6)

45.4 / 45.5 x 4 (3) = 182 g / 0.182 kg (3)

(iii) GIVE: **stronger intermolecular (London dispersion, Van der Waals', dipole-dipole) forces (attractions) / higher mass / bigger molecules / polarity of C to O bond / has more electrons** (3)
[To allow opposite points Helium must be mentioned.]

(b)(i) STATE: **equal (same) volumes of gases contain equal (same) numbers of molecules (particles, moles)** (4)
under same conditions* of temperature and pressure (3)
[* Do not accept "under all conditions".] [Do not accept "at s.t.p."]

Question 8 (2006 - Section B - Question 11 - Part (a))

(a) (i) WHAT: perfectly **obeys the gas laws (Boyle's law, kinetic theory, $PV = nRT$)** under all conditions of temperature and pressure (4)

(ii) GIVE: **intermolecular forces (attractions between molecules, named correct inter-molecular force) / molecules have volume (molecules take up space, volume of molecules not negligible) / collisions not** perfectly **elastic** ANY ONE: (3)

(iii) MOLES: **0.03** mol (9)

PV = nRT $1 \times 10^5 \times \mathbf{720 \times 10^{-6}} = n \times 8.3 \times \mathbf{283}$ (2 x 3) n = **0.03** (3)	$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$ $\frac{1 \times 10^5 \times 720}{\mathbf{283}} = \frac{1 \times 10^5 \text{ (or } 1.013 \times 10^5) \times V_2}{273}$ V_2 = 685 to 695 (2 x 3) ÷ **22400** = **0.03** (3)

[Marks in context of correct operations. *Not given correct to one significant figure* (–1)]

(iv) MOLECULES: $\mathbf{1.8 \times 10^{22}}$ (3)

$0.03 \times 6 \times 10^{23} = 1.8 \times 10^{22}$ (3)

(v) MASS: **2.22** g (6)

0.03 mol CO_2 ≡ 0.03 mol $Ca(OH)_2$ (3)** 0.03 x 74* = 2.22 (3) [* *Addition must be shown for error to be treated as a slip.*]

** *Can be given for 1 : 1 ratio or for 0.03 mol $Ca(OH)_2$*

Question 9 (2005 - Section B - Question 11 - Part (b))

(b) (i) DEFINE: has **as many** (same **number of) particles* as 12 g (0.012 kg) of carbon-12** / contains the **Avogadro number (Avogadro constant, *L*, 6 x 10^{23})** of **particles*** / the relative **formula mass (molecular mass) in grams (g)** (7)
[Accept "*atoms*", "*ions*" or "*molecules*" in place of "*particles*"]

(ii) STATE: **equal (same) volumes of gases contain equal (same) numbers of molecules (particles, moles)** (3)
under same conditions of temperature and pressure *(Do not accept "at s.t.p.")* (3)
[Allow 3 marks for *"one mole of a gas at s.t.p. occupies 22.4 litres"*]

(iii) HOW MANY: $\mathbf{2.4 \times 10^{22} - 2.5 \times 10^{22}}$ atoms (12)

10 % (v/v) = 10 cm^3 per 100 cm^3 / 10 litres per 100 litres	(3)
=> volume of helium = 1 litre	(3)
= $^1/_{24}$ mol / $0.041\dot{6}$ mol	(3)
x 6×10^{23} = $2.4 \times 10^{22} - 2.5 \times 10^{22}$ atoms	(3)

Question 10 (2012 - Section A - Question 3)

(a) GIVE: **propanone (acetone)** (56 °C) / **propanal** (49 °C) / **methanol** (65 °C) / **trichloro-methane {chloroform}** (61 °C) / **hexane** (69 °C) / **other suitable liquid** (5)
[Accept **ethanol** (78 °C), **ethyl ethanoate** (77 °C), **cyclohexane** (81 °C).*]*
[Accept formula].

(b) *(i)* Apparatus **A***

weigh flask + fittings // heat **until** all **liquid gone (until vaporised)** , **cool, dry and reweigh** // mass is **difference (find difference)**

or

Apparatus **B***

weigh small syringe + contents // **inject liquid and reweigh** // mass is **difference (find difference)** (3 × 3)

(ii) Apparatus **A***

fill flask with water **and empty into measuring (graduated) cylinder**

or

Apparatus **B***

read volume **from** scale of **gas syringe** / find **diff. between** initial and final **readings** (6)

(c) EXPL: **the pinhole (in apparatus A*) means //**
vapour exposed to (in contact with) the **air (atmosphere) / vessel is open to atmosphere**

or

the **plunger** (in apparatus **B***) **is free to move (moves)** //
until vapour pressure reaches atmospheric pressure (until pressure is equal inside and outside) / plunger **stops when pressure equalises** (2 × 3)
*N.B. Marks to be awarded for either **A** or **B** and not for a mixture; if the candidate gives answers for both methods, mark them separately and award the marks for the better of the two.*

(d) MOL: **0.01076** [*Allow* **0.01** to **0.011** mol] (9)

equation of state (correct)	(3)
$\frac{101 \times 10^3 \times 330 \times 10^{-6}}{8.3 \times 373}$	(3)
= **0.01076 to 0.011**	(3)

or

$\frac{V_{room}}{293^*} = \frac{330}{373}$	(3)
V_{room} = **259** cm^3	(3)
259 ÷ 24000 = **0.0108**	(3)

**similar method at s.t.p.*

M_r : **57** to **63** (6)

0.63 ÷ **0.01076 to 0.011**	(3)
= **57 to 63**	(3)

(e) WHY: **do not vaporise easily / boiling points too high / boiling points too near (higher than) boiling point of water / boiling points too near (higher than) 100 °C (373 K)** / **have to vaporise below 100 °C** (3)

WHAT: **mass spectrometer** (6)