

M1.(a) The molecules (continually) move about in random motion ✓

Collisions of molecules with each other and with the walls are elastic ✓

Time in contact is small compared with time between collisions ✓

The molecules move in straight lines between collisions ✓

ANY TWO

Allow reference to 'particles interact according to Newtonian mechanics'

2

(b) Ideas of pressure = F / A and $F =$ rate of change of momentum ✓

Mean KE / rms speed / mean speed of air molecules increases ✓

More collisions with the inside surface of the football each second ✓

Allow reference to 'Greater change in momentum for each collision'

3

(c) Radius = $690 \text{ mm} / 6.28 = 110 \text{ mm}$ or $T = 290 \text{ K}$ ✓ seen

volume of air = $5.55 \times 10^{-3} \text{ m}^3$ ✓

$n \times 29(\text{g}) = 11.4 (\text{g})$ ✓ $n = 0.392 \text{ mol}$

$$\frac{0.392 \times 8.31 \times 290}{}$$

Use of $pV = nRT = 5.55 \times 10^{-3} \text{ m}^3$ ✓

$p = 1.70 \times 10^5 \text{ Pa}$ ✓

Conclusion: Appropriate comparison of their value for p with the requirement of the rule, ie whether their pressure above $1 \times 10^5 \text{ Pa}$ falls within the required band ✓

Allow ecf for their n V and T ✓

6

[11]

M2.C

- M3.(a) the number of atoms in 12g of carbon-12
or the number of particles / atoms / molecules in one mole of substance ✓
not – N_A quoted as a number

1

- (b) (i) mean kinetic energy ($= 3 / 2 kT$) $= 3 / 2 \times 1.38 \times 10^{-23} \times (273 + 22)$
 $= 6.1 \times 10^{-21}$ (J) ✓
 6×10^{-21} J is not given mark

1

- (ii) mass of krypton atom
 $= 0.084 / 6.02 \times 10^{+23}$ ✓
($= 1.4 \times 10^{-25}$ kg)
 $\overline{c^2} (= 2 \times \text{mean kinetic energy} / \text{mass})$

$$= 2 \times 6.1 \times 10^{-21} / 1.4 \times 10^{-25}$$

$$= 8.7 - 8.8 \times 10^4$$

$$\text{m}^2 \text{s}^{-2} \text{ or } \text{J kg}^{-1}$$

1st mark is for the substitution which will normally be seen within a larger calculation.

allow CE from (i)

working must be shown for a CE otherwise full marks can be given for correct answer only

no calculation marks if mass has a physics error i.e. no division by N_A note for CE

answer = (i) $\times 1.43 \times 10^{25}$

3

- (c) (at the same temperature) the mean kinetic energy is the same
or

gases have equal $\frac{1}{2} m \overline{c_{rms}^2}$

or

mass is inversely proportional to mean square speed / $m \propto 1 / \overline{c^2}$ ✓

$\overline{c^2}$ or mean square speed of krypton is less ✓

1st mark requires the word mean / average or equivalent in an algebraic term

2nd mark 'It' will be taken to mean krypton. So, 'It is less' can gain a mark

allow 'heavier' to mean more massive'

allow vague statements like speed is less for 2nd mark but not in the first mark

2

[7]

- M4.(a)** molecules have negligible volume
collisions are elastic
the gas cannot be liquified
there are no interactions between molecules (except during collisions)
the gas obeys the (ideal) gas law / obeys Boyles law etc.
at all temperatures/pressures
any two lines ✓✓

a gas laws may be given as a formula

2

(b) (i) $n (= PV / RT) = 1.60 \times 10^6 \times 0.200 / (8.31 \times (273 + 22))$ ✓
 $= 130$ or 131 mol ✓ (130.5 mol)

2

(ii) mass = $130.5 \times 0.043 = 5.6$ (kg) ✓
(5.61kg)

allow ecf from bi

density (= mass / volume) = $5.61 / 0.200 = 28$ ✓ (28.1 kg m^{-3})
 kg m^{-3} ✓

a numerical answer without working can gain the first two marks

3

(iii) ($V_2 = P_1 V_1 T_2 / P_2 T_1$)
 $V_2 = 1.6 \times 10^6 \times .200 \times (273 - 50) / 3.6 \times 10^4 \times (273 + 22)$ or $6.7(2) \text{ (m}^3)$ ✓

allow ecf from bii

[reminder must see bii]

look out for

mass remaining = $5.61 \times 0.20 / 6.72 = 0.17$ (kg) ✓ (0.167 kg)

or

$n = (PV / RT = 3.6 \times 10^4 \times 0.200 / (8.31 \times (273 - 50))) = 3.88(5)$ (mol) ✓

mass remaining = $3.885 \times 4.3 \times 10^{-2} = 0.17$ (kg) ✓

2 sig figs ✓

any 2 sf answer gets the mark

3

[10]

M5. (a) (i) $n = PV/RT = 3.2 \times 10^5 \times 1.9 \times 10^{-3} / 8.31 \times 285$

$n = 0.26 \text{ mol}$ ✓ (0.257 mol)

1

(ii) $P_2 = \frac{T_2}{T_1} \times P_1 = \frac{295}{285} \times 3.20 \times 10^5$ ✓

$3.31 \times 10^5 \text{ Pa}$ ✓ (allow $3.30\text{-}3.35 \times 10^5 \text{ Pa}$)

3 sig figs ✓ sig fig mark stands alone even with incorrect answer

3

(b) similar - (rapid) **random** motion

- range of speeds

different - **mean** kinetic energy

- root **mean** square speed

- **frequency** of collisions

2

[6]