**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 mm / 6.28) = 110 mm or $T$ = 290 K ✓ seen

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

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

Use of $pV = nRT$ = $\dfrac{0.392 \times 8.31 \times 290}{5.55 \times 10^{-3}\ \text{m}^3}$ ✓

$p = 1.70 \times 10^5$ Pa ✓

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

*Allow ecf for their n V and T* ✓

**6**

**[11]**

**M2.**C

[1]

**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 × 1.38 × $10^{-23}$ × (273 + 22)
= 6.1 × $10^{-21}$ (J) ✓

*6 × $10^{-21}$ J is not given mark*

**1**

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

= 2 × 6.1 × $10^{-21}$ / 1.4 × $10^{-25}$)
= 8.7 - 8.8 × $10^{4}$ ✓
$m^2\ s^{-2}$ or 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) × 1.43 × $10^{25}$*

**3**

(c) (at the same temperature) the mean kinetic energy is the same
or
gases have equal $\frac{1}{2}mc_{rms}^2$
or
mass is inversely proportional to mean square speed / m ∝ 1 $/\overline{c^2}$ ✓
$\overline{c^2}$ or mean square speed of krypton is less ✓

*1st mark requires the word <u>mean / average</u> 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 × $10^6$ × 0.200 / (8.31 × (273 + 22)) ✓
= 130 or 131 mol ✓ (130.5 mol)

2

(ii) mass = 130.5 × 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 × $10^6$ × .200 × (273 – 50) / 3.6 × $10^4$ × (273 + 22) or 6.7(2) ($m^3$)* ✓

*allow ecf from bii*

***[reminder must see bii]***
*look out for*

mass remaining = 5.61 × 0.20 / 6.72 = 0.17 (kg) ✓ (0.167 kg)
or
*n* = (*PV* / *RT* = 3.6 × $10^4$ × 0.200 / (8.31 × (273 − 50)) = 3.88(5) (mol) ✓

mass remaining = 3.885 × 4.3 × $10^{-2}$ = 0.17 (kg) ✓
2 sig figs ✓

*any 2 sf answer gets the mark*

3

**[10]**

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

$n = 0.26$ mol ✓ (0.257 mol)

**1**

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

$3.31 \times 10^5$ Pa ✓(allow 3.30-3.35 × $10^5$ 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]**