| Question | Answer | Marks |
|---|---|---|
| **1** | A | 1 |
| **2** | C | 1 |
| **3** | $pV = nRT$<br>$V = \frac{nRT}{p} = \frac{3 \times 8.31 \times 300}{3.0 \times 10^5}$<br>$= 0.025\ \text{m}^3$ (2 s.f.) | 1<br>1<br>1 |
| **4 a** | The pressure will increase by a factor of 4. | 1 |
| **4 b** | Molecules in the gas interact with each other via Van der Waal's forces, which cause a transfer of energy between molecules. | 1<br>1 |
| **5** | $\Delta U = mc\Delta T$<br>Power is the rate of change of energy with time, $\frac{\Delta U}{\Delta t}$<br>So $P = \frac{mc\Delta T}{\Delta t}$ or $\frac{\Delta T}{\Delta t} = \frac{P}{mc}$<br>$= \frac{1500}{0.7 \times 4200} = 0.5\ \text{K s}^{-1}$ | 1<br>1 |
| **6 a i** | $m = \rho V = 1.2\ \text{kg m}^{-3} \times 4.2\ \text{m}^3 = 5.04\ \text{Kg}$<br>Number of moles $= \frac{\text{mass}}{\text{mass per mole}} = \frac{5.04\ \text{kg}}{0.029\ \text{kg mol}^{-1}}$<br>$= 170$ mol (2 s.f.) | 1<br>1<br>1 |
| **6 a ii** | Mass of mole of carbon = mass of molecule × number of molecules in a mole.<br>Mass of a mole of carbon $= 7.3 \times 10^{-26}\ \text{kg} \times 6.02 \times 10^{23} = 0.043\ldots\ \text{kg}$<br>Number of moles $= \frac{\text{mass}}{\text{mass per mole}} = \frac{1.5\ \text{kg}}{0.043\ldots\ \text{kg}} = 34$ moles (2 s.f.) | 1<br>1<br>1 |
| **6 a iii** | $pV = nRT$<br>So $p = \frac{nRT}{V} = \frac{(173 + 34)\ \text{mol} \times 8.31\ \text{J mol}^{-1}\ \text{K}^{-1} \times 270.15\ \text{K}}{4.2\ \text{m}^2}$<br>$= 1.2 \times 10^5$ Pa (2 s.f.) | 1<br>1 |
| **6 b** | Reasonable suggestions can include:<br>• Sudden pressure changes can be harmful/fatal to humans.<br>• Sudden temperature changes can be harmful/fatal to humans.<br>• Fire extinguisher release could cause a distraction to the driver.<br>• Increase in carbon dioxide/decrease in oxygen can be harmful/fatal to humans. | Any 2 |
| **7 a i** | $pV = \frac{1}{3} Nmc_{rms}^2 = NRT$<br>$c_{rms}^2 = \frac{3RT}{m} = \frac{3RT}{0.0399}$ | 1<br>1 |
| **7 a ii** | Kinetic energy per mass of atom $= \frac{1}{2} c_{rms}^2 = \frac{3}{2} \frac{RT}{0.0399}$<br>1 argon atom $= \frac{0.0399}{6.02 \times 10^{23}}$ kg<br>Therefore $E_k = \frac{3}{2} \frac{8.31}{6.02 \times 10^{23}} (274 - 273)$<br>$= 2 \times 10^{-23}$ J (1 s.f.)<br>This is a mean value because it uses the root mean square speed. | 1<br>1<br>1<br>1 |

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| **7 b** | $c = \frac{\Delta U}{m\Delta\theta} = \frac{2\times10^{-23}}{\frac{0.0399}{6.02\times10^{23}}\times1}$<br>$= 300\ \text{J K}^{-1}$ (1 s.f.) | 1<br><br>1 |
| **7 c** | As the temperature rises, the volume will increase ($V \propto T$).<br>Work has to be done to increase the volume of the gas<br>and so more energy would be required to heat the gas with a changing volume. | 1<br>1<br>1 |
| **8 a** | $pV = nRT$ hence $p_1V_1 = p_2V_2$<br>so $p_2 = p_1\frac{V_1}{V_2} = 2.0\times10^5\times3$<br>$= 6.0\times10^5$ Pa | <br>1<br>1 |
| **8 b** | $pV = \frac{1}{3}Nmc_{rms}^2 = NRT$<br>so $c_{rms}^2 = \frac{3RT}{m} = \frac{3\times8.31\times300}{0.004}$<br>$= 2\times10^6\ \text{m s}^{-1}$ (1 s.f.) | <br>1<br>1 |
| **8 c** | $c_{rms}^2 = \frac{3RT}{m}$ So $\frac{c_{rms(400K)}^2}{c_{rms(300K)}^2} = \frac{\left(\frac{3R\times400}{m}\right)}{\left(\frac{3R\times300}{m}\right)} = \frac{4}{3}$<br>So $\frac{c_{rms(400K)}}{c_{rms(300K)}} = \sqrt{\frac{4}{3}}$ | 1<br><br>1 |
| **9 a** | Mass of $N_2 = \frac{2.8\times10^{-2}}{6.02\times10^{23}} = 5\times10^{-26}$ kg (1 s.f.) | 1 |
| **9 b** | $\frac{1}{2}mv^2 = \frac{3}{2}kT$<br>Thus $v = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3\times1.4\times10^{-23}\times300}{5\times10^{-26}}}$<br>$= 500\ \text{m s}^{-1}$ (1 s.f.) | <br>1<br>1 |
| **9 c i** | Speed $= \frac{\text{distance}}{\text{time}}$, thus, time $= \frac{\text{distance}}{\text{speed}} = \frac{7.0}{500}$<br>$= 0.014 \approx 0.015$ s | 1<br>1 |
| **9 c ii** | Relevant points can include e.g.:<br>• Gas particles have a finite size and so collide.<br>• Each collision changes the direction of the particle.<br>• Each collision changes the speed of the particle.<br>• As a result, particles do not travel in a direct line or with a constant speed. | Any 3 |
| **9 d** | Relevant points can include e.g.:<br>• The rate of diffusion will be lower.<br>• The larger molecules collide more often/travel less far before a collision.<br>• The distance travelled is proportional to the square root of the number of collisions.<br>• And a shorter distance is travelled between each collision | Any 3.<br>Award no marks if the answer states the rate of diffusion as higher. |