Name: …………………… Class: ………… Marks: ………./ 19 Time: 30 mins

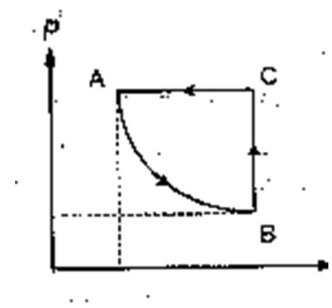
TUTORIAL 11: TEMPERATURE AND IDEAL GAS QUIZ

1	2	3	4	5	6

1. The absolute temperature of an ideal gas is directly proportional to which of the following properties, when taken as an average, of the molecules of that gas?

A speed **B** momentum **C** mass **D** kinetic energy

2. A mass of an ideal gas of volume V, at pressure P undergoes a cycle of changes as shown in the diagram below, where T_A, T_B and T_C are the temperatures at states A, B, and C respectively. Which of the following best describes the relationship between T_A, T_B, and T_C?



A $T_A = T_B$, $T_A < T_C$
B $T_A < T_B < T_C$
C $T_B < T_A < T_C$
D $T_A < T_C$, $T_B < T_C$

3. The molecules of an ideal gas at thermodynamic (absolute) temperature *T* have a root-mean-square speed, $c_{r.m.s}$. The gas is heated to temperature 2*T*. What is the new root-mean-square speed of the molecules?

A $\sqrt{2}\, c_{r.m.s}$ **B** $2\, c_{r.m.s}$ **C** $2\sqrt{2}\, c_{r.m.s}$ **D** $4\, c_{r.m.s}$

4. How many moles of air must escape from a 10m × 8.0m × 5.0m room when the temperature is raised from 0°C to 20°C? Assume the pressure remains unchanged at one atmosphere while the room is heated. (1 atm = 1×10^5 Pa)

A 1.3×10^3 **B** 1.2×10^3 **C** 7.5×10^2 **D** 3.7×10^2

5. The density of helium at 273 K and 100 kPa is 0.178 kgm^{-3}. What is the root-mean-square speed of its particles?

A 130 ms^{-1} **B** 232 ms^{-1} **C** 753 ms^{-1} **D** 1300 ms^{-1}

6. In deriving the equation $p = 1/3\, \rho \langle c^2 \rangle$, which of the following is not taken as a valid assumption?

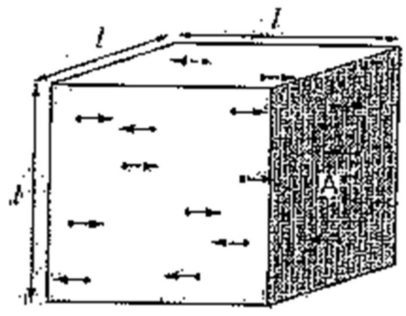
A The volume of the molecules is negligible compared with the volume of the gas.

B The duration of a collision is negligible compared with the time between collisions.

C Collisions with the walls of the container and with other molecules cause no change in the average kinetic energy of the molecules.

D The molecules suffer negligible change of momentum on collision with the walls of the container.

7 **(a)** Consider a cubicle box of side l which contains N molecules, each of mass m, all moving horizontally with speed u at right angles to wall A.



When a molecule hits a wall, it bounces off with no loss of speed and travels in the opposite direction. Deduce

(i) The momentum of a molecule just before a collision with the wall,

(ii) The change in momentum of a molecule when it collides with the wall,

(iii) The time taken by one molecule between collisions with wall A,

(iv) The total number of collisions per unit time made with wall A by all the molecules,

(v) The rate of change of momentum for all the molecules colliding with wall A

[7]

(b) Use your answer to part (a) to show that the pressure p on wall A is given by

$$p = \frac{Mu^2}{V}$$

Where M is the total mass of all the molecules and V is the internal volume of the box.

[2]

(c) The conditions considered in (a) are highly improbable. Explain briefly how the conditions may be altered to provide a better model of an ideal gas. State, without proof, how the equation in (b) might be modified. [4]

Temperature and Ideal Gas Quiz Solutions

1	2	3	4	5	6
D	D	A	B	D	D

1 Ans: D

2 Ans: D

There are no values on the graph to suggest that A is the same or different from B.

3 Ans: A

Since $KE \alpha T$, $v^2 \alpha T$, $c_{r.m.s} \alpha \sqrt{T}$

$$\frac{c_1}{\sqrt{T_1}} = \frac{c_2}{\sqrt{T_2}}$$

$$c_2 = c_1\sqrt{\frac{T_2}{T_1}} = c_{r.m.s}\sqrt{\frac{2T}{T}} = \sqrt{2}c_{r.m.s}$$

4 Ans: B

Using $pV = nRT$, where p and V constant,

At $0°C$,

$$n_1 = \frac{pV}{RT_1} = \frac{(1\times10^5)(10\times8.0\times5.0)}{8.31(273.15)} = 1.76\times10^4 \text{ mol}$$

$$n_1T_1 = n_2T_2$$

$$n_2 = n_1\frac{T_1}{T_2} = 1.76\times10^4\frac{273.15}{20+273.15} = 1.64\times10^4 \text{ mol}$$

Therefore, moles that escape = $(1.76-1.64)\times10^4 = 1.2\times10^3$ mol

5 D
Using $p = 1/3\ \rho\langle c^2\rangle$

6 D
Every collision with the wall resulted in a large change in momentum, not negligible.

7(a)
(i) mu [1]
(ii) 2mu [1]
(iii) 2l/u [1]
(iv) Nu/(2l) [2]
(v) 2mu x Nu/(2l) = Nmu^2/l [2]

(b) P = Force/Are = $Nmu^2/l^3 = Mu^2/V$ [2]

(c) Molecules cannot be expected to move only in the horizontal direction. [1]

A better model is to allow the molecules to have <u>equal probability</u> to move in <u>x, y and z</u> directions. [2]

A better equation is $p = M\langle c^2\rangle/(3V)$, where $\langle c^2\rangle = \langle u_x^2\rangle + \langle u_y^2\rangle + \langle u_z^2\rangle$ [1]