AQA A-LEVEL PHYSICS · 7408

PHYSICS



MARK SCHEME

3.6.2.3 MOLECULAR KINETIC THEORY MODEL

SCORE	PERCENTAGE
/12	%

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Q1.

(a) The volume / size of the gas molecules is negligible / point mass or point molecule

Or molecules are point masses

Or small compared to the volume / size occupied by of the gas ✓ owtte

No mark for all the same size or spherical.

Without the comparison the word used must suggest extremely small.

Zero volume is wrong.

1

(b) (using $N = PV/kT$)

$N = (1.0 \times 10^5 \times 0.70 \times 10^{-3}/(1.38 \times 10^{-23} \times 300)$ ✓ (first mark is for converting the temperature to kelvin and using it in a valid equation)

$N = 1.7 \times 10^{22}$ molecules ✓ (1.69×10^{22} molecules)

Alternatively (using $n = PV/RT$)

$n = (1.0 \times 10^5 \times 0.70 \times 10^{-3} / 8.31 \times 300) = 0.028$ mol ✓ (first mark is for converting the temperature to kelvin and using it in a valid equation)

$N (= n N_A = 0.028 \times 6.02 \times 10^{23}) = 1.7 \times 10^{22}$ molecules ✓ (1.69×10^{22} molecules)

Correct answer scores both marks

Power of 10 issue = AE

Temperature conversion = PE

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(c) (using $T_B = T_A V_B / V_A$)

$T_B = 300 \times 0.50 / 0.70 = 214$ (K) ✓

Change in temperature (= 214 – 300) = (–) 86 (K)✓

Or

$T_B (= PV/Nk) = 1.0 \times 10^5 \times 0.50 \times 10^{-3}/(1.38 \times 10^{-23} \times 1.69 \times 10^{22}) = 214$ (K) ✓

Change in temperature (= 214 – 300) = (–) 86 (K)✓ (± 1 K)

Or

$T_B = (PV/nR) = 1.0 \times 10^5 \times 0.50 \times 10^{-3} /(0.028 \times 8.31) = 215$ (K) ✓

Change in temperature (= 215 – 300) = (–) 85 (K)✓

Correct answer scores both marks

Let the last mark stand alone provided an attempt at calculating T_B is made.

Also allow working in Celsius for this last stand-alone mark.

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(d) An appropriate calculation might be:

(If the temperature remained constant $P_C = P_B V_B / V_C$)

$P_C = 1.0 \times 10^5 \times 0.50 \times 10^{-3} / 0.30 \times 10^{-3} = 1.7 \times 10^5$ (Pa) ✓

(but the pressure at C is higher than this so) the temperature at C is different / higher / not constant ✓

Or

(If the temperature remained constant $P_C V_C$ would equal $P_B V_B$)

$P_B V_B = 1.0 \times 10^5 \times 0.50 \times 10^{-3} = 50$

$P_C V_C = 2.05 \times 10^5 \times 0.30 \times 10^{-3} = 61$ ✓

(*P V* is not equal) the temperature at C is different / higher / not constant ✓

Or a full calculation can be given using $P V / T$ = constant.

$P_B V_B / T_B = 1.0 \times 10^5 \times 0.5 \times 10^{-3} / 214 = (0.234 \text{ J K}^{-1})$

$T_C = P_C V_C$ / constant $= 2.05 \times 10^5 \times 0.30 \times 10^{-3} / 0.234$

$T_C = 263$ K ✓

the temperature at C is different / higher / not constant ✓

On its own higher temperature scores 0. ***Additionally there must be a reference to a correct calculation to obtain the last mark.***

The question only requires the candidate to spot a change. The two marks are for each side of a comparison.

Complete figures are not always required. For example in the last alternative the common factor 10^5 could be missing.

2nd alternative may come from a ratio.

Depending on the sig figs used in the substitution of data the temperature has a range 256 – 270 K

PV = NkT may be used as another alternative.

On a few occasions the full paper may be required to view.

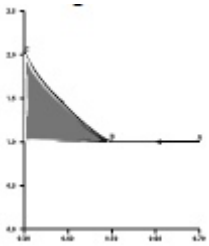
2

(e) work done on gas from **A** to **B** (using $W = P\Delta V$ or W = area under the graph $= 1.0 \times (0.70 - 0.50) \times 10^{-3}$) $= 20$ (J) ✓
giving a reference to the work done being the area under the graph ✓

The third mark can be obtained in the following ways:

calculating the area indicated corresponds to the <u>additional work</u> done on the gas from **B** to **C**

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(166 mm^2 where 1 mm^2 = 0.05 J) = 8.3 J √
(allow 8.0 – 10.0 J)

Or

The total work done (566 mm^2 where 1 mm^2 = 0.05 J) =
28.3(J) ✓

(allow 28.0 – 30.0 J)

This second mark can be obtained from an attempt at an area calculation that involves the curved section of the graph.

NB '<u>additional</u> work' must be quoted to give mark for 8 – 10 J.

This 3rd mark is for a correct evaluation and not for details of the process.

3

[10]

Q2.

C

[1]

Q3.

D

[1]

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Q1.

(a) Some less able students did not adhere to the limitations of the question, which only required information about the size of molecules. Many simply stated an assumption used in kinetic theory. Apart from this, the question gave good discrimination. The main misconception was that all molecules have to be the same size and the 'near miss answer' was to state that molecules must be small without giving any relative measure.

(b) It was only the less able students who failed to get full marks in this calculation. The main errors were to use the temperature in Celsius when Kelvin should have been used, or to have arithmetic errors. Also some scripts showed an obvious confusion between n moles and N molecules.

(c) Here, again, the majority of students found the question straightforward and either used the proportionality between volume and pressure, or used the ideal gas equation to calculate the new temperature. Other students seemed to make up their own equations or, again, had trouble over which temperature units to use.

(d) This turned out to be a discriminating question. What distinguished the more able student was not only to have the knowledge to calculate the new temperature, but the ability to deduce what must remain constant if the temperature was constant. They then could interpret their calculations in a clear fashion. They could provide a statement as simple as, 'if the temperature were constant then PV would be constant, which is not the case'. Less able students tended to give an array of numbers with very little calculation. They also showed errors in substituting the wrong data.

(e) Students found this question very difficult, with only about one third scoring any marks. A majority did not have the knowledge even to perform the first task that involved $W = P\Delta V$. Many launched into 'internal energy of a gas' equations. As a result, some of these thought that negative work was done on the gas, because the temperature falls between A and B. Not many students were aware of the connection between work done on the gas and the area under a $P - V$ graph. Even the students who did know, calculated the area from B to C incorrectly by only considering the increase in area.

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