Thermal Physics Retest

2016

Name:

Class:

Time:

Marks:

Comments:

1 (a) Explain what is meant by

(i) the specific heat capacity of water,

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....

(ii) the specific latent heat of fusion of ice.

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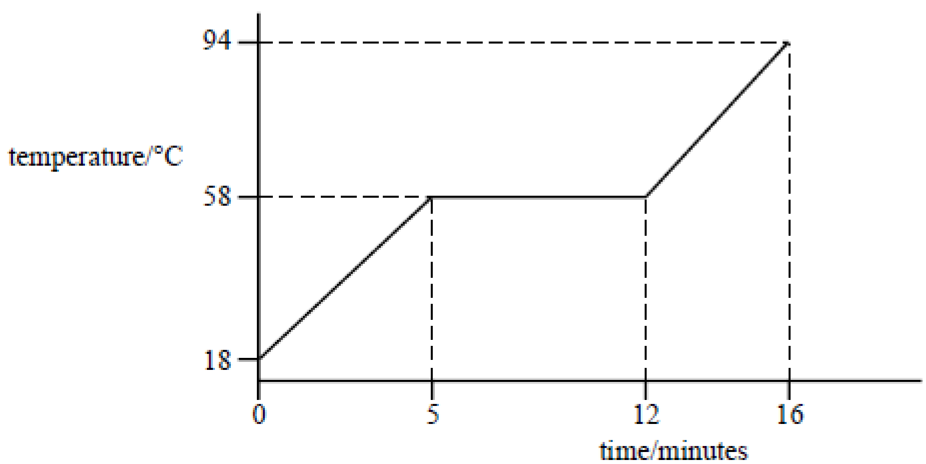
(4)

(b) A sample of solid material, which has a mass of 0.15 kg, is supplied with energy at a constant rate. The specific heat capacity of the material is 1200 J kg^{-1} K^{-1} when in the solid state. During heating, its temperature is recorded at various times and the following graph is plotted.



Assume there is no heat exchange with the surroundings.

(i) Show that energy is supplied to the material at a rate of 24 W.

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(ii) Calculate the specific latent heat of fusion of the material.

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(iii) Calculate the specific heat capacity of the material when in the liquid state.

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(6)
(Total 10 marks)

2 (a) A cylinder of fixed volume contains 15 mol of an ideal gas at a pressure of 500 kPa and a temperature of 290 K.

(i) Show that the volume of the cylinder is 7.2×10^{-2} m^3**.**

....

....

(ii) Calculate the average kinetic energy of a gas molecule in the cylinder.

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(4)

(b) A quantity of gas is removed from the cylinder and the pressure of the remaining gas falls to 420 kPa. If the temperature of the gas is unchanged, calculate the amount, in mol, of gas remaining in the cylinder.

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(2)

(c) Explain in terms of the kinetic theory why the pressure of the gas in the cylinder falls when gas is removed from the cylinder.

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(4)
(Total 10 marks)

3 (a) State **two** quantities which increase when the temperature of a given mass of gas is increased at constant volume.

(i) ....

(ii) ....

(2)

(b) A car tyre of volume 1.0×10^{-2} m^3 contains air at a pressure of 300 kPa and a temperature of 290K. The mass of one mole of air is 2.9×10^{-2} kg. Assuming that the air behaves as an ideal gas, calculate

(i) n, the amount, in mol, of air,

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....

(ii) the mass of the air,

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....

(iii) the density of the air.

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....

(5)

(c) Air contains oxygen and nitrogen molecules. State, with a reason, whether the following are the same for oxygen and nitrogen molecules in air at a given temperature.

(i) The average kinetic energy per molecule

....

....

....

....

(ii) The r.m.s. speed

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(4)
(Total 11 marks)

4 A raindrop of mass m falls to the ground at its terminal speed v. The specific heat capacity of water is c and the acceleration of free fall is g. Given that 25% of the energy is retained in the raindrop when it strikes the ground, what is the rise in temperature of the raindrop?

A $\frac{mv^2}{8c}$

B $\frac{v^2}{4mc}$

C $\frac{mg}{4c}$

D $\frac{v^2}{8c}$

(Total 1 mark)

5 A car of mass M travelling at speed V comes to rest using its brakes. Energy is dissipated in the brake discs of total mass m and specific heat capacity c. The rise in temperature of the brake discs can be estimated from

A $\frac{mV^2}{2Mc}$

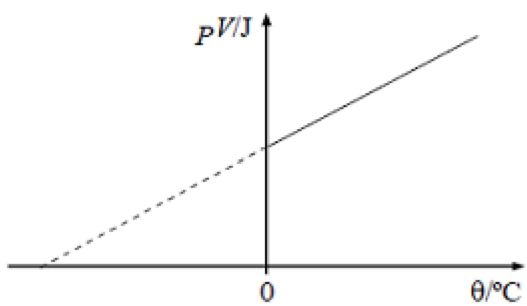
B $\frac{2MV^2}{mc}$

C $\frac{MV^2}{2mc}$

D $\frac{2mc}{MV^2}$

(Total 1 mark)

6 The graph shows the relation between the product *pressure* × *volume*, pV, and temperature, θ, in degrees celsius for 1 mol of an ideal gas for which the molar gas constant is R.



Which one of the following expressions gives the gradient of this graph?

A $\frac{1}{273}$

B $\frac{pV}{\theta}$

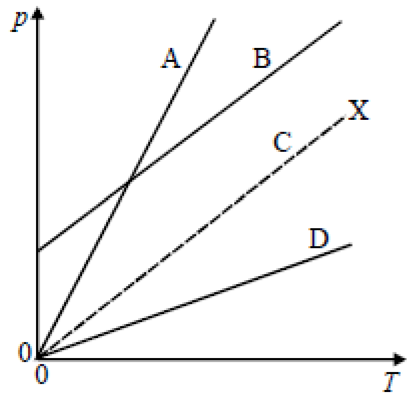
C $\frac{pV}{(\theta - 273)}$

D R

(Total 1 mark)

7 In the diagram the dashed line **X** shows the variation of pressure, p, with absolute temperature, T, for 1 mol of an ideal gas in a container of fixed volume.

Which line, **A**, **B**, **C** or **D** shows the variation for 2 mol of the gas in the same container?



(Total 1 mark)

Mark schemes

1 (a) (i) quantity of energy supplied to unit mass **(1)**

which raises temperature by 1°C [or 1K] **(1)**

(ii) quantity of energy required to change state of unit mass **(1)**

solid to liquid [or ice to water] **(1)**

without change of temperature **(1)**

(max 4)

(b) (i) Q (= $mc\Delta\theta$) = 0.15 × 1200 × (58 – 18) = 7200 (J) **(1)**

$P = \dfrac{7200}{5 \times 60}$ = 24 W **(1)**

(ii) Q = 24 × 7 × 60 = 10080 (J) **(1)**

$0.15l$ = 10080 gives l = 67200 J kg^{-1} **(1)**

(iii) 24 × 4 × 60 = 0.15 × s_L × (94 – 58) **(1)**

gives s_L = 1070 J kg^{-1} K^{-1} **(1)**

(6)

[10]

2 (a) (i) $p\,V = nR\,T$ **(1)**

$V = \dfrac{15 \times 8.31 \times 290}{500 \times 10^3}$ **(1)** (gives V = 7.2 × 10^{-2}m^3)

(ii) (use of $E_k = \dfrac{3}{2}kT$ gives) $E_k = \dfrac{3}{2}$ × 1.38 × 10^{-23} × 290 **(1)**

= 6.0 × 10^{-21} (J) **(1)**

4

(b) (use of $pV = nRT$ gives) $n = \dfrac{420 \times 10^3 \times 7.2 \times 10^{-2}}{8.31 \times 290}$ **(1)**
[or use $p \propto n$]

n = 13 moles **(1)** (12.5 moles)

2

(c) pressure is due to molecular bombardment [or moving molecules] **(1)**
when gas is removed there are fewer molecules in the cylinder
[or density decreases] **(1)**

(rate of) bombardment decreases **(1)**
molecules exert forces on wall **(1)**

$\overline{c^2}$ is constant **(1)**

[or $pV = \frac{1}{3} Nm (c^2)$ **(1)**

V and m constant **(1)**

(c^2) constant since T constant **(1)**

$p \propto N$ **(1)**]

[or $p = \frac{1}{3}$ p(c^2) **(1)**

explanation of ρ decreasing **(1)**

(c^2) constant since T constant **(1)**

p (c^2) ρ **(1)**]

max 4

[10]

3 (a) (i) pressure **(1)**

(ii) (average) kinetic energy
[or rms speed] **(1)**

(2)

(b) (i) $pV = nRT$ **(1)**

$$n = \frac{1.0 \times 10^{-2} \times 300 \times 10^3}{8.31 \times 290}$$ **(1)**

= 1.20 (mol) **(1)** (1.24 mol)

(ii) mass of air = 1.24 × 29 × 10^{-3} = 0.036 kg **(1)**
(allow e.c.f from(i))

(iii) $\rho = \frac{0.0360}{1 \times 10^{-2}} = 3.6\ \mathrm{kg\,m^{-3}}$ (allow e.c.f. from (ii))

(5)

(c) (i) same **(1)**
because the temperature is the same **(1)**

The Quality of Written Communication marks were awarded primarily for the quality of answers to this part.

(ii) different **(1)**
because the mass of the molecules are different **(1)**

(4)

[11]

4 D

[1]

5 C

[1]

6 D

[1]

7 A

[1]

Examiner reports

1 It seemed that some centres had overlooked, or not had sufficient time to cover, the topic of heat calculations. Definitions of specific heat capacity and specific latent heat in part (a) were often very good and were awarded all four marks. A common misconception was that heat must be *supplied* to water in order to change it to ice.

The calculations in part (b) were sometimes missed out completely or often misunderstood, but occasionally completed perfectly. Many candidates who were able to justify the 24W in part (b)(i) were then stumped by parts (b)(ii) and (b)(iii). In both of these parts the incorrect use of 7200J was very common. The answer to part (b)(iii) was often penalised because it was quoted to an excessive number of significant figures.

2 There were significant variations between candidates. Most were able to correctly apply the equation of state for an ideal gas but were less confident when it came to calculating in part (a) the average kinetic energy of a gas molecule in the cylinder. It was evident that a significant number of candidates did not know the appropriate formula. In part (c) explaining, in terms of the kinetic theory, why the pressure of the gas fell was well answered. The only common error was assuming that the kinetic energy of molecules fell even though the temperature remained constant.

3 In part (a) most candidates could only give one correct quantity. This was usually pressure. Very few gave the average kinetic energy. The calculation in part (b) was generally well done, with the most common error being the inability to convert kPa to Pa. This however only incurred a one-mark penalty.

Candidates found part (c) much more difficult and even those who knew the correct answer were often not able to express themselves clearly. It was apparent from many answers that candidates could remember the appropriate equations but were not as secure in their conceptual understanding.