PHYSICS REVISION
TEMPERATURE / IDEAL GAS / TEMPERATURE

Q8

(a)

Using $PV = nRT$,

$n = PV/RT$ [1]

$\frac{28000 \times 420}{8.31 \times 225} = 6289.6 = 6290$ moles [1]

(b)

$$P_A V_A^{1.4} = P_B V_B^{1.4}$$

$(28 \times 10^3)(420)^{1.4} = P_B(28)^{1.4}$ [1]

Pressure after compression, $P_B = 1.24 \times 10^6$ Pa (Shown)

(c)

Using $PV = nRT$,

$T_B = \frac{1.24 \times 10^6 \times 28}{6290 \times 8.31} = 665K$ (shown) [1]

(d)

Using $PV = nRT$,

$P_C = \frac{6290 \times 8 \cdot 31 \times 1400}{28}$ [1]

= 2610 kPa [1]

(e)

Heat supplied per sec

= 6290 x 20.8 x (1400 - 665) [1]

= 96.3 MJ s^{-1} [1]

(f)

Total amount of fuel used (by four engines)

$= \frac{96.3 \times 10^6}{53 \times 10^6} \times 6 \times 3600 \times 4$ [2]

= 157×10^3 kg [1]

(g)

Using $PV = nRT$,

$T_D = \frac{720 \times 28 \times 10^3}{6290 \times 8.31} = 386K$ [1]

(h)

	Increase in internal energy of gas/ MJ	Heat supplied to gas/ MJ	Work Done on gas/ MJ
A to B	57.4	0	57.4
B to C	96.3	96.3	0
C to D	-132.7	0	-132.7
D to A	- 20.7	-29.1	8.4

Total : [4]

(i)

From (i) net work output by an engine = - 57.4 + 132.7 - 8.4 = 66.9 MJ [1]

efficiency of engine = $\frac{66.9}{96.3}$ = 0.695 [1]

(j)

Actual Power of engine = Fv = 220 kN X 250 = 55 MJ [1]

Efficiency of the engine in practice = $\frac{55.0}{96.3}$ = 0.571 [1]

(3) (a) (i) $PV = nRT$

$P = \frac{nRT}{V}$

$P = \frac{5 \times 8.31 \times 298}{0.027}$

$P = 4.59 \times 10^5$ Pa

$F = PA$

$F = 4.59 \times 10^5 \times 0.09$

$F = 4.13 \times 10^4$ N

(ii) $\sqrt{<c^2>} = \sqrt{\frac{3RT}{M}}$

$\sqrt{<c^2>} = \sqrt{\frac{3 \times 8.31 \times 298}{0.0202}}$

$\sqrt{<c^2>} = 606$ m s^{-1}

(iii) Since $U = \frac{3}{2}NkT$, and there is no change in temperature, the internal energy of the gas will remain the same.

(b) (i) $\Delta W = -P(V_B - V_A) = -6000$ J

$\Delta U = Q + W = 21 - 6 = 15$ kJ

$U_B = U_A + \Delta U = 30 + 15 = 45$ kJ

MCQ Answers

1	B	6	D	11	A
2	B	7	B	12	D
3	C	8	A	13	B
4	B	9	D	14	A
5	B	10	A	15	C

3 (a) In the absence of bearing friction, a winding machine would raise a cage weighing 1000 kg at 10 m s^{-1}, but this is reduced by friction to 9 m s^{-1}.

(i) What is the rate of dissipation of wasteful heat?

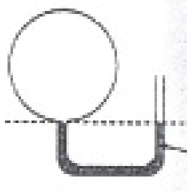
Rate of work done by the machine without friction = mgh = 1000 x 9.81 x 10 = 9.81 x 10^4 W
Rate of work done by the machine with friction = mgh = 1000 x 9.81 x 9 = 8.83 x 10^4 W
Rate of wasteful heat is the work done against friction = 9.81 x 10^4 - 8.83 x 10^4 = 9.8 kW

(ii) How much oil, initially at 20°C, is required per second to keep the temperature of the bearings down to 70°C? (Specific heat capacity of oil = 2100 J kg^{-1} K^{-1}) [3]

Rate of wasteful heat is the work done against friction = 9.81 x 10^4 - 8.83 x 10^4 = 9.8 kW

Rate of heat gained by oil = (m/t) c $\Delta\theta$ = 9.8 kW
(m/t) = 9.8 x 10^3 / (2100 x (70 – 20)) = 0.0933 kg s^{-1}

(b) A glass sphere of volume 7.0 X 10^3 cm^3 contains air at 27°C and is attached to a pipe full of mercury as shown.



Initially the mercury is level with the bottom of the sphere in both arms of the tube, and the outside pressure is 760 mm Hg. The air in the sphere is then heated so that the mercury level is raised by 5 mm in the outer arm.

(i) If the cross-sectional area of the pipe is 10 cm^2, what is the increase in the volume of the heated air? [2]

Increase in volume of air in cylinder = 5 mm x 10 cm^2
= 5 x 10^{-3} x 10 x (10^{-2})^2
= 5 x 10^{-6} m^3

(ii) What is the final temperature of the air in the sphere? [3]

Assuming air behaves as an ideal gas, $P_1V_1 / T_1 = P_2V_2 / T_2$
760 x 7.0 x 10^3 / (273 + 27) = (760 + 5) x (7.0 x 10^3 + 5 x 10^{-6}) / T$_2$
T$_2$ = 301.9 K
= 28.9 °C = 29 °C

3c. No energy is transferred into or out of the system by heat:
Work is done on the system as a result of the agitation (Kinetic energy is increased).
Both temperature and internal energy will increase.

3di. $Q = mc\Delta\theta$

$$\Delta\theta = \frac{Q}{mc}$$

$$\Delta\theta = \frac{m_s l_v + m_s c_s \Delta\theta_s}{(mc)_{milk}}$$

$$\Delta\theta = \frac{1.00\times10^{-3}(2.2\times10^6 + 4.2\times10^3\times20.0)}{0.15\times4.0\times10^3} = 3.8K$$

for correct calculation of heat released by steam
OR stating that Heat Gained by Milk = Heat Lost by Steam **to 80°C**
for correct substitution
for final answer

3dii. Assume that <u>all steam has condensed</u> to form water.
OR Assume that steam was initially at 100°C.
OR Assume that there was no loss of mass through evaporation.

ci. Area represents the change in momentum (impulse) during each collision on wall by a gas molecule.

ii. 2mv x N = 2(0.004/6.02 x10^{23}) x 1420 x 100 = 1.9 x 10^{-21} Ns

iii. (½ x F$_{max}$ x 0.002) x 100 = 1.9 x 10^{-21}
F$_{max}$ = 1.9 x 10^{-20} N

Can't be done because not enough data given

iv. He should use F$_{max}$ for safety because that's the highest force exerted on the wall.

3(a) In the evaporation process, liquid molecules need to overcome intermolecular forces of attraction to separate themselves from other molecules and become independent. [1] In addition, the molecules need to do work in expansion against the external atmosphere as they go from the liquid into the vapour or gaseous phase. [1] In the melting process, the molecules need only to break away from the solid structure to have a higher degree of freedom and disorder in the liquid state. Negligible work is done against the atmosphere in the case of melting. [1] Hence the specific latent heat required in the evaporation process is greater than that in the melting process.

(b)(i) It is to eliminate the rate of heat lost to the surroundings from the equations in the calculations. [1]

(b) (ii) By Law of Conservation of Energy,
power supplied = power needed to vaporise liquid + rate of heat loss to surroundings. [1]

$$VI = \frac{dm}{dt} l_v + h$$

1st expt:

$$150\times2.5 = \frac{0.478}{20\times60} l_v + h \text{ --- (1)} \quad [1]$$

2nd expt:

$$111\times2.0 = \frac{0.264}{20\times60} l_v + h \text{ --- (2)} \quad [1]$$

Solving (1) and (2):
$\boldsymbol{l_v = 8.58 \times 10^5}$ **J kg^{-1}** [1]

(b)(iii) Solving (1), (2): h = 33.3 W [1]
Heat loss in 20 min = ht
= 33.3 x 20 x 60 = **3.99 x 10^4 J** [1]

(d)(i) T2 =367 K
(ii) 0.18.3%