ANSWERS

CHAPTER TP1

1.1 D.

Comments on suggested answers.

A: The caloric theory was based on experiments, usually in the form of observation of everyday experience.

B: No. Rather it fitted in with the experimental facts - different bodies needing different amounts of caloric to heat them, caloric being squeezed out of objects by friction.

C: Rumford certainly showed that the fluid was weightless but that did not destroy the theory. It showed the fluid was peculiar but, after all, electromagnetic waves are weightless.

D: This was the real stumbling block. It took too much of an effort of the imagination to postulate an infinite amount of fluid in a finite body. Re-read Rumford's own comment.

1.2 (a) Caloric is squeezed out of the match and/or the side of the match box. There is so much fluid squeezed out that the match catches fire.

(b) The work done in pushing the match along the box increases the internal energy of the system to such an extent that a special chemical reaction can occur.

1.3 The energy change is

potential energy → kinetic energy → internal energy.

So the increase in internal energy is equal to the decrease in potential energy;

i.e $6\text{ kg} \times 9.8\text{ m.s}^{-2} \times 10\text{ m} = 0.6\text{ kJ}$

1.4 No. The internal energy of the gas is unchanged. This is so because we are arranging things so as to keep the temperature of the gas constant. The energy going into the gas as work done on it is escaping to the surroundings as heat flow.

1.5 The initial conditions are $P = 101$ kPa and $V = 5 \times 10^{-2}\text{ m}^3$, so PV, which is constant, remains as 5 kJ.

1.6 Total work done = force × displacement

= 40 N × 120 m

= 4.8 kJ.

Now 4.2 kJ is required to raise the temperature of 1 kg of water by 1°C so the temperature of the bath water (100 kg) is raised by a little more than 0.01°C.

CHAPTER TP2

2.1 For any value of density between 999.84 kg.m^{-3} and 1000.0 kg.m^{-3} there are two possible values of temperature. Hence if the density were measured and found to be within this range, no unique value of temperature could be assigned. If, however, the use of the density of water as a thermometric property was restricted to temperatures greater than 4°C, say, there would be no problem as temperature is a single valued function of density in this range. Hence we see that any thermometric property is suitable for use as a thermometer only over a temperature range where its magnitude steadily increases or decreases as a function of temperature. This consideration is of importance in relation to thermocouples.

2.2 18°C.

CHAPTER TP3

3.1 Energy required to evaporate all the water

= Energy needed to raise temperature to 100°C + energy needed to evaporate at 100°C

$= m\,c\,\Delta T + m\,L$

$= 2.0\text{ kg} \times 4.2 \times 10^{3}\text{ J.kg}^{-1}\text{.K}^{-1} \times 80\text{ K} + 2.0\text{ kg} \times 2.26 \times 10^{6}\text{ J.kg}^{-1}$

$= (6.72 \times 10^{5} + 4.52 \times 10^{6})\text{ J}$

$= 5.19 \times 10^{6}\text{ J}.$

Amount of energy as heat flow available = 6.0 MJ.

So all the water is evaporated.

3.2 (i) (a) is adiabatic; there is no heat flow into cylinder.

(ii) (b) is isochoric; the volume of the cylinder is constant.

(iii) (c) is isobaric; the weight on the piston keeps the pressure in the cylinder constant.

3.3 The internal energy of the body is increased when we eat food. The energy is added in the form of the potential energy of the chemical binding forces which hold the food molecules together.

Chemical changes are brought about in the stomach and cells, and as a result, some of this potential energy becomes available for the doing of external work and a large part appears as heat.

3.4 Number of large squares inside loop ≈ 7

The area of one square represents $0.10 \times 10^{-3}\ m^3 \times 0.10 \times 10^{3}\ Pa$

$= \quad 1.0 \times 10^{-2}\ N.m$

Hence the work done by the lung in one breathing cycle is $7 \times 1.0 \times 10^{-2}\ J = 0.07\ J$

3.5 38 K.

The fact that the specific heat of the body is similar to that of water should not be surprising; the body is about 60% water by weight.

3.6 Rate of heat removal $= \quad (0.01\ kg.s^{-1}) \times (4.2 \times 10^{3}\ J.kg^{-1}.K^{-1}) \times (2.1\ K)$

$= \quad 88.2\ W$

This will be equal to the person's rate of heat production.

3.7 Heat capacity of thermometer $= \quad (0.010 \times 140 + 0.007 \times 840) J.K^{-1}$

$= \quad 7.3\ J.K^{-1}$

Heat capacity of water and beaker $= \quad (0.10 \times 4200 + 0.040 \times 840) J.K^{-1}$

$= \quad 453.6\ J.K^{-1}$.

If T is the original temperature of the water and beaker:

$7.3\ J.K^{-1}\ (61.5 - 15.0)°C \quad = \quad 453.6\ J.K^{-1}\ (T - 61.5°C)$

Hence $T = (61.5 + 0.8°)\ °C \quad = \quad 62.3°C$

CHAPTER TP4

4.1 Tossing a head: 1/2.

Tossing two successive heads: 1/4.

Tossing ten successive heads: $\frac{1}{2^{10}} = \frac{1}{1024}$.

4.2 Chance of winning one lottery $= \frac{1}{10^{5}}$.

Chance of winning two in succession $= \frac{1}{10^{10}}$.

If an event has a 1 in 10^{20} chance of occurring it would be equivalent to winning 4 lotteries in a row.

4.3 No. In falling we have gravitational potential energy transformed to kinetic energy and then to internal energy of the shattered man and his surroundings. From the energy point of view, there is no reason why the process could not be reversed.

If we look at the process from the point of view of the first law, work has been done on the man by gravity and some heat flow to the surroundings has occurred after contact with the rocks. Nothing in the first law prevents this flow of heat back into the man, and for his increased internal energy to do work against gravity, propelling him back to the top of the cliff.

This situation does not occur in nature,so there must be a law, additional to the law of conservation of energy, that deals with the direction in which energy changes can occur.

4.4 The smoke from the engine is retreating into the funnel rather than emerging from it.