Chapter 14
Multiple choice and quick questions

1. What is the order in increasing energy of the three particles in the situations listed below?

   1: K.E. of an electron accelerated through 30 volts

   2: K.E. of an air molecule at room temperature

   3: K.E. of an alpha-particle emitted from the nucleus of an atom increasing energy

A 2 3 1 **B** 2 1 3 **C** 1 2 3 **D** 1 3 2 **E** 3 2 1

2. In a certain chemical reaction, pairs of particles only combine when they collide with an energy greater than E. When the temperature T is 300 K, E is about 10 times the average energy kT of the particles.

   Which one of the following is a good way of estimating how much faster the reaction goes at 330 K compared with 300 K?

   The arithmetic is correct in each case, but in only one is the argument correct.

   A about 5% faster, because the average speed of the particles has increased by about this amount

   B about 10% faster, because the average energy kT of the particles has increased by 10%

   C about 2.5 times faster, because $e^{-E/kT}$ has increased by about 2.5 times

   D about 3 times faster, because

$$\frac{330 - 300}{E/T}$$

   is about 3, where T is the average of 300 and 330

   E about 10 times faster, because E/kT is still close to 10

3. An experimenter records the values of the current I in a thermistor at various temperatures T. The experimenter wishes to test the relationship:

   I µ $P\ e^{-A/T}$ where A and P are constants

   If the relationship is correct, which quantities should be plotted to obtain a straight line?

A I against $1/T$ **B** $1/I$ against $1/T$ **C** I against 1nT **D** 1nI against T

E 1nI against $1/T$

4. In a new design for a power station the predicted maximum thermodynamic efficiency is 60% when the surroundings are at 300 K. Which one of **A** to **E** below gives the assumed temperature of the energy source?

A 18000K **B** 1800 K **C** 750K **D** 500 K **E** 450 K

5. The energy, e, required for a water molecule to go from the liquid into the vapour is about 3×10^{-20}J.

(a) Calculate the Boltzmann factor $e^{-e/kT}$ for the vaporisation of water at 300 K.

Boltzmann factor = …………

(b) State the units of the quantity kT

Units = ………

6. In a mixture of particles which are in equilibrium at temperature T, the particles will have various energies; the number n_{low} having a certain energy E and the number n_{high} having energy $E + \Delta E$ are related by the formula (A) below:

$$\frac{n_{high}}{n_{low}} = e^{\frac{-\Delta ?}{kT}}$$

where k is the Boltzmann constant.

This question is concerned with how the formula might be applied to the molecules in the Earth's atmosphere.

(a) Write down an expression for the difference DE in gravitational potential energy of a molecule of mass m at ground level and the same molecule raised to a small height h above the Earth's surface:

(b) Now rewrite the formula (A) in terms of:

- the energy difference you have given at (a)
- the number of molecules per unit volume n_o at the Earth's surface
- the number of molecules per unit volume n_h at height h in the Earth's atmosphere.