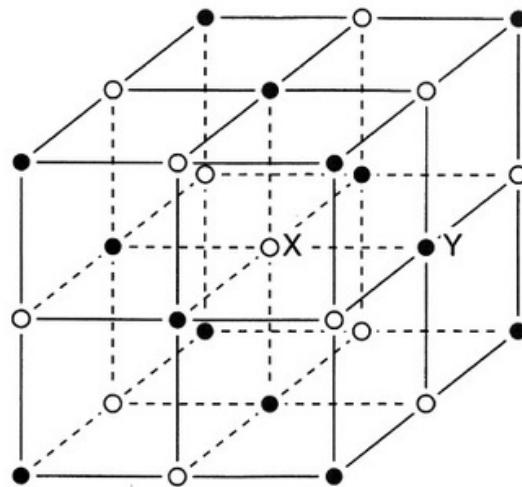


- 7 When some substances are in the solidstate, they exist as positively-charged and negatively-charged ions arranged in a cubiclattice, as illustrated in Fig. 7.1.



**Fig. 7.1**

A starting point for the understanding of lattice energies is to consider the potential energy  $E_p$  between two ions X and Y.

Fig. 7.2 shows the variation with the distance  $r$  between X and Y of  $E_p$ .

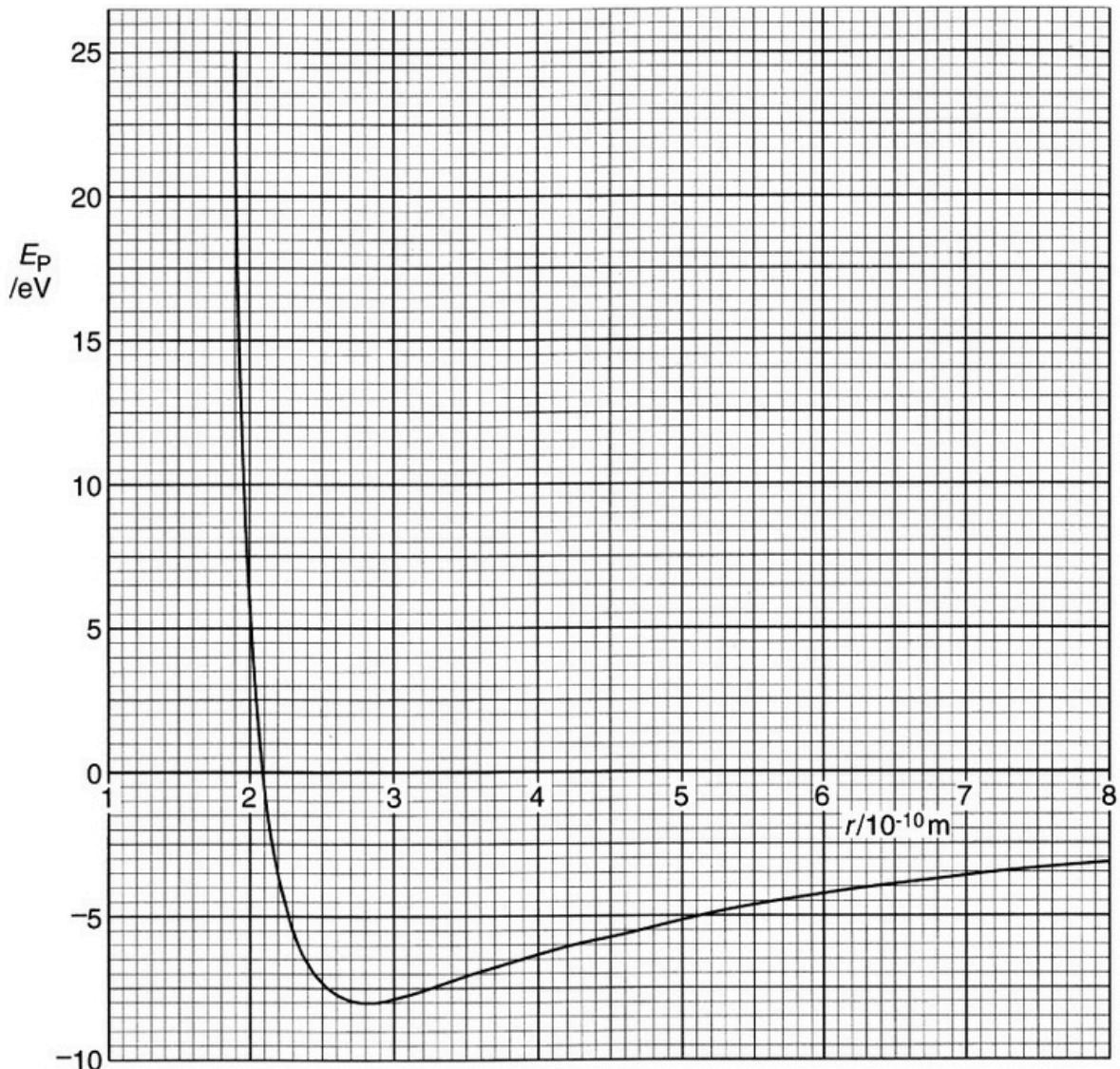


Fig.7.2

- (a) (i) The gradient  $G$  of the graph varies with the distance  $r$ . Show that, starting from the definition of *work done*, for any value of  $r$  the magnitude of the force  $F$  between X and Y is given by the expression

$$F = G.$$

.....

.....

.....

.....

[2]

- (ii) Suggest how Fig. 7.2 indicates that, for some values of  $r$ , the force between X and Y is attractive and, for other distances, the force is repulsive.

.....  
.....  
.....

[2]

- (iii) Use Fig. 7.2 and the expression in (i) to determine the magnitude of the force, in newton, for values of the distance  $r$  equal to

1.  $2.8 \times 10^{-10}$  m,

force = ..... N [1]

2.  $5.0 \times 10^{-10}$  m.

force = ..... N [3]

- (b) The variation with distance  $r$  of the potential energy  $E_p$  may be represented by the expression

$$E_p = -\frac{A}{r} + \frac{B}{r^8}$$

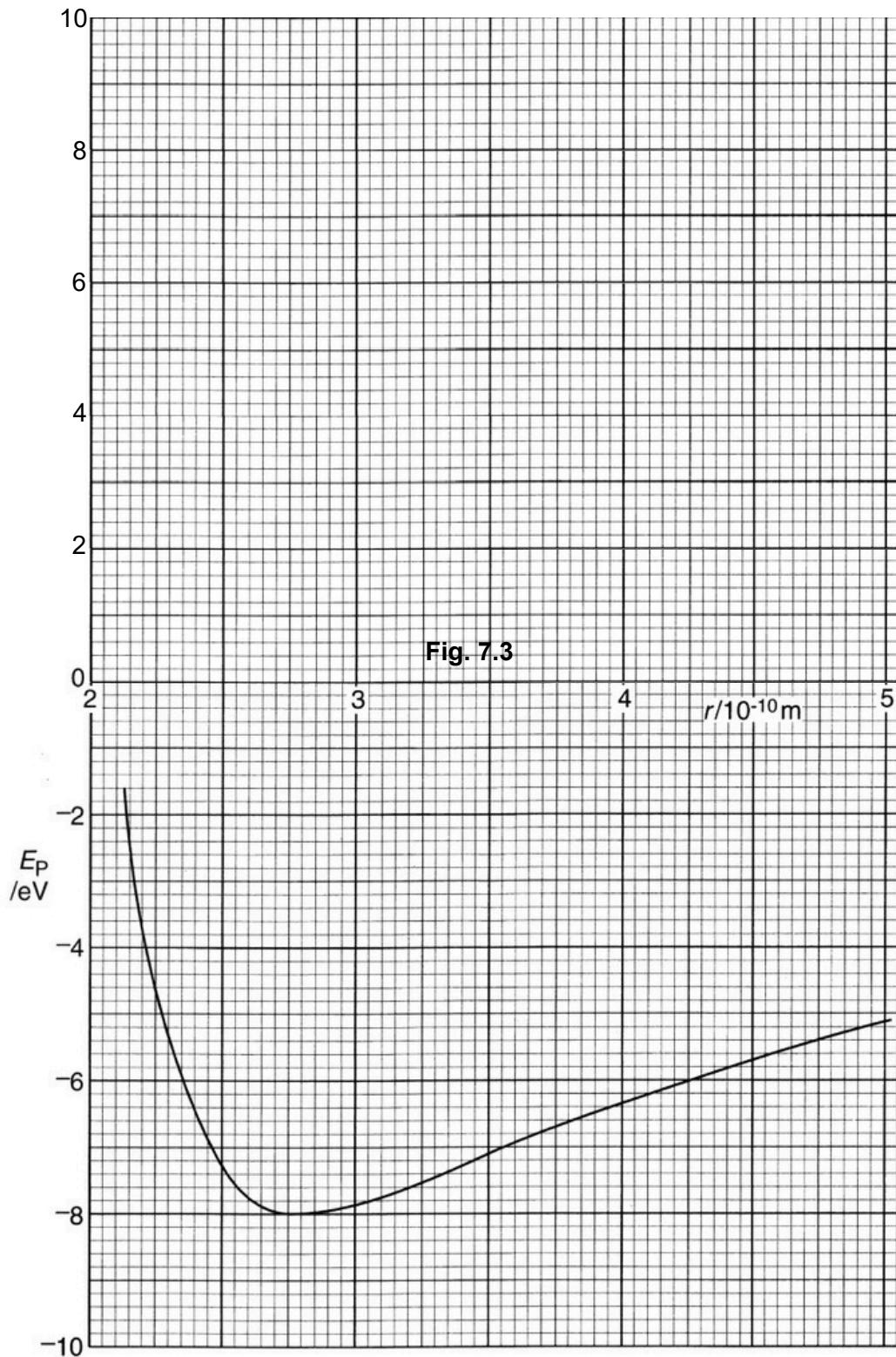
where  $A$  and  $B$  are constants.

By reference to Fig. 7.2, state two features of the force represented by the term  $\frac{B}{r^8}$  in this expression.

1. ....  
.....  
.....
2. ....  
.....

[2]

(c) Fig. 7.3 shows part of Fig. 7.2, drawn on a larger scale.



**Fig. 7.3**

Thermal energy of the ions causes them to vibrate.  
The ions have a total energy of  $-6.0 \text{ eV}$ .

(i) On Fig. 7.3,

1. draw the variation with the distance  $r$  of the total energy of the ions. Label the line T. [1]

2. draw the variation with the distance  $r$  of the kinetic energy of the ions. Label the line K. [2]

- (ii) Use Fig. 7.3 to determine, for these ions, the values of  $r$  between which they vibrate.

minimum value of  $r = \dots \text{m}$

maximum value of  $r = \dots \text{m}$  [2]

(iii) State and explain whether the oscillations of the ions are simple harmonic.

.....

.....

..... [2]

(d) By reference to Fig. 7.3, suggest why the dimensions of the whole lattice increase as it is heated.

.....

.....

..... [3]

[Total: 20]