7 When some substances are in the solid state, they exist as positively-charged and negatively-charged ions arranged in a cubic lattice, as illustrated in Fig. 7.1.

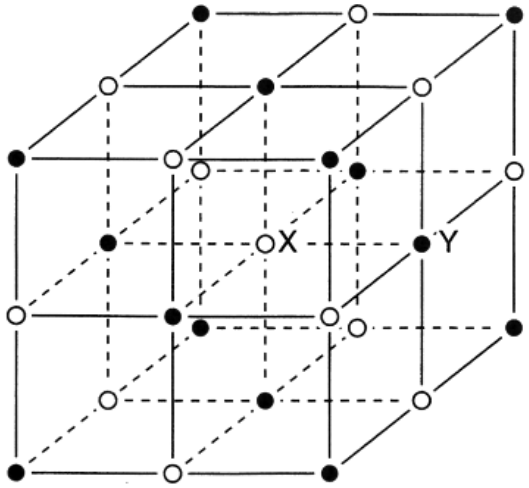


Fig. 7.1

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.

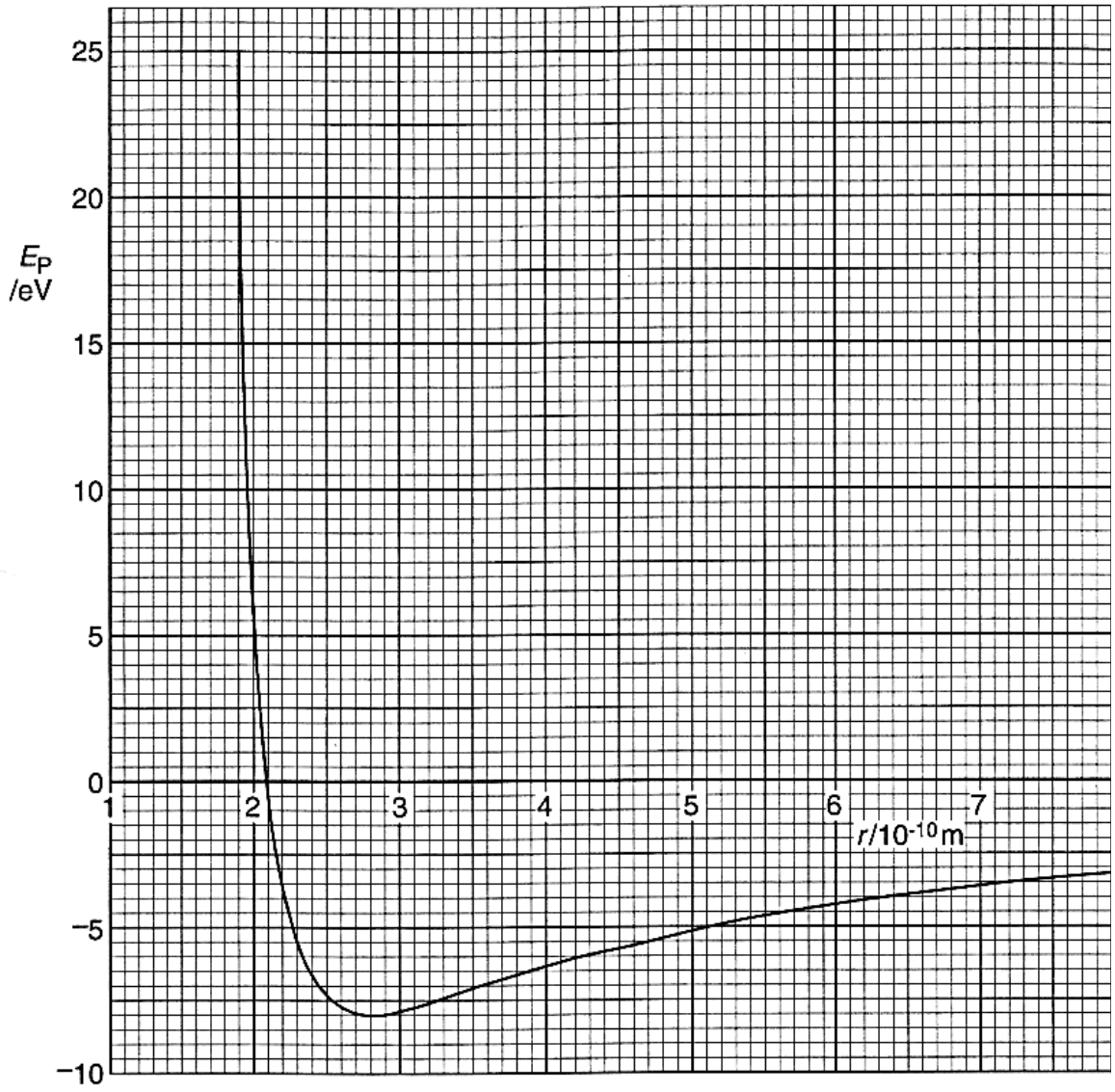


Fig. 7.2

(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 **(a)(i)** to determine the magnitude of the force, in newton, for distance *r* at

1. 2.8×10^{-10} m,

force = ……N [1]

2. 5.0×10^{-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. ……

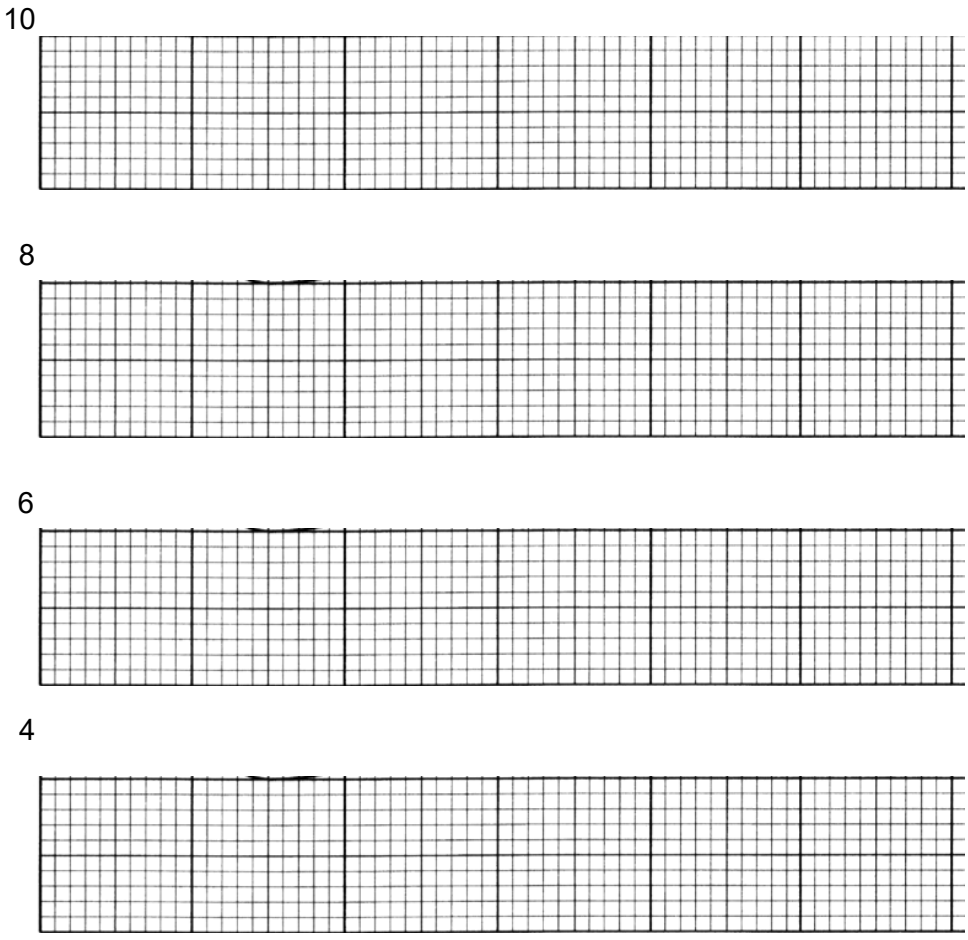
……

2. ……

.....

[2]

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



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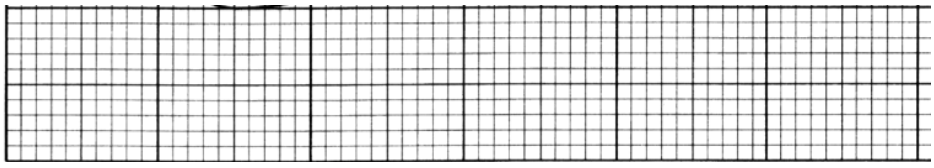

Fig. 7.3

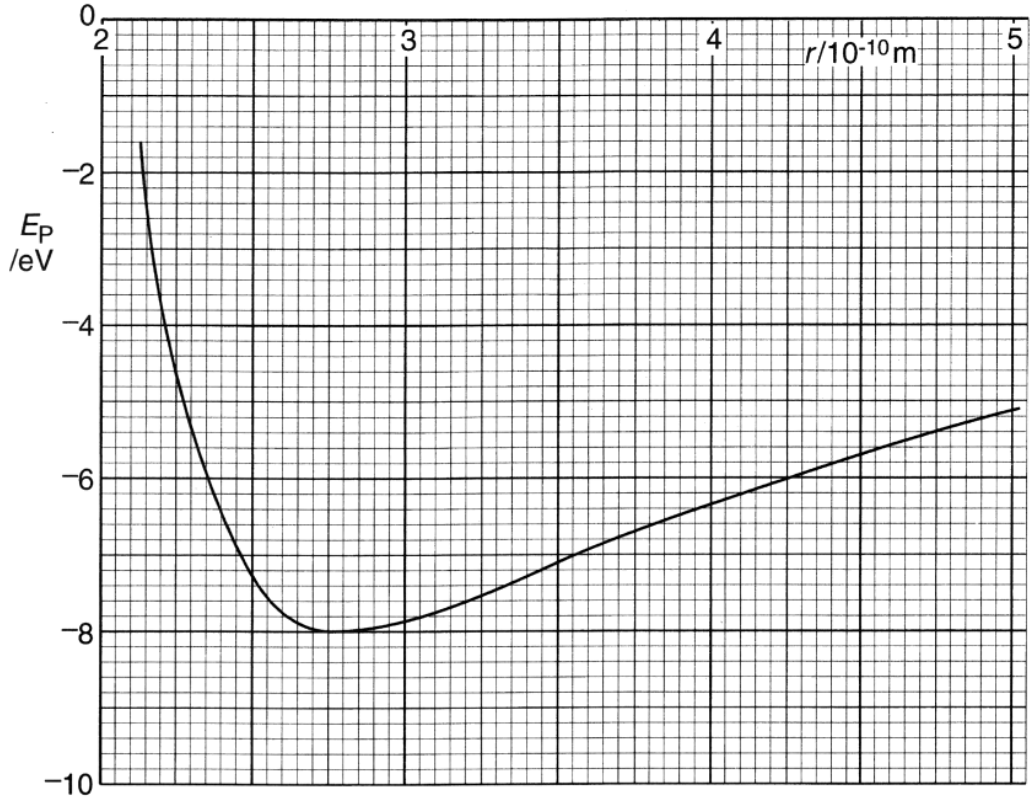

Fig. 7.3

(i) Thermal energy of the ions causes them to vibrate.

The ions have a total energy of **-** 6.0 eV.

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* = ……..m

maximum value of *r* = ……..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]

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