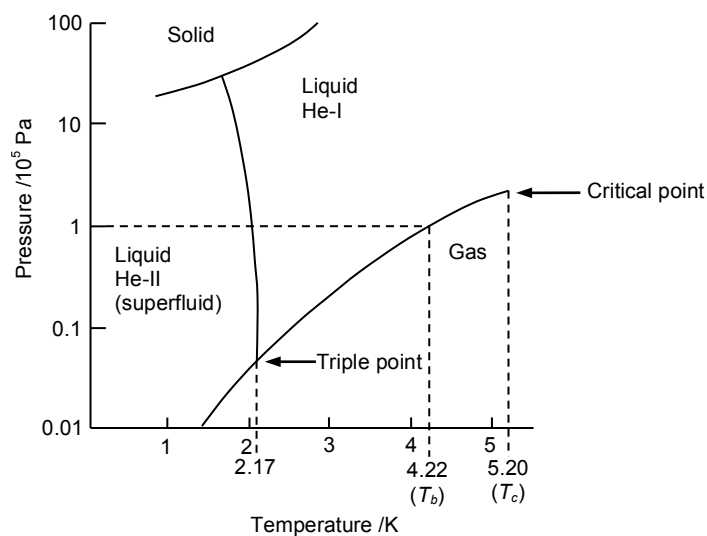


- The diagram below shows a simplified phase diagram of helium.



Describe two unusual properties of helium (other than the “superfluid” He-II phase) that are *not* shared by most substances.

The unusual properties of helium that can be deduced from the phase diagram include:

- (i) It has 2 triple points.
- (ii) There is no gas/solid equilibrium line (*i.e.* helium does not sublime).
- (iii) There is a liquid/liquid equilibrium line.
- (iv) The triple points involve 2 liquid phases.
- (v) helium cannot exist as a solid at atmospheric pressure.

Is it possible to liquefy helium above 5.20 K? Explain your answer.

No. If $T > 5.2$ K, helium exists as a supercritical fluid above $\sim 2 \times 10^5$ Pa and as a gas below this pressure.

Why is the liquefaction of He very difficult, even at low temperatures?

Intermolecular forces between He atoms are extremely weak.

The electrons are held very tightly in the small 1s orbital. The atom is therefore very small and the electron cloud is not very polarisable. As a result, the interatomic dispersion forces required for liquefaction are very weak and they can only sufficient to keep He atoms in a liquid phase at temperatures approaching absolute zero.