

Chemguide – answers

RAOULT'S LAW AND IDEAL MIXTURES OF LIQUIDS

1. a) The partial vapour pressure of a component in a mixture is equal to the vapour pressure of the pure component at that temperature multiplied by its mole fraction in the mixture.

b) (i) Total number of moles = 5

So mole fraction of A = $1/5 = 0.2$

Partial vapour pressure of A = mole fraction x vapour pressure of pure component
= $0.2 \times 10 \text{ kPa} = 2 \text{ kPa}$

(ii) Similarly:

Partial vapour pressure of B = mole fraction x vapour pressure of pure component
= $0.8 \times 12.5 \text{ kPa} = 10 \text{ kPa}$

(iii) Total vapour pressure = $2 + 10 \text{ kPa} = 12 \text{ kPa}$

c) (i) The mixture of butan-1-ol and butan-2-ol (mixture C) is likely to be almost ideal. The mixture of ethanol and pentane (mixture D) is unlikely to be ideal.

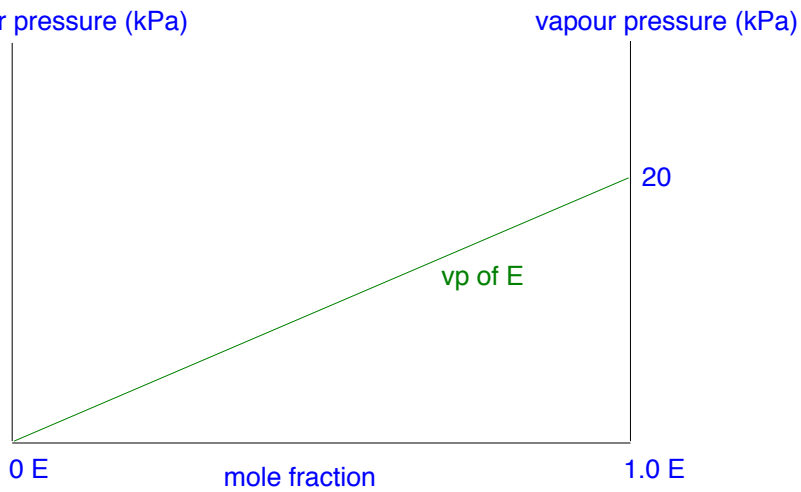
(ii) A mixture will be ideal if the forces of attraction between the different particles in the mixture is exactly the same as the forces of attraction between the particles in the pure liquids. That means that all the particles in the mixture will have the same tendency to escape into the vapour as in the original liquids.

In the case of the mixture of alcohols, both are the same size, and have the same intermolecular forces - van der Waals dispersion forces, dipole-dipole attractions and hydrogen bonds. Those same forces will also be present in the mixture.

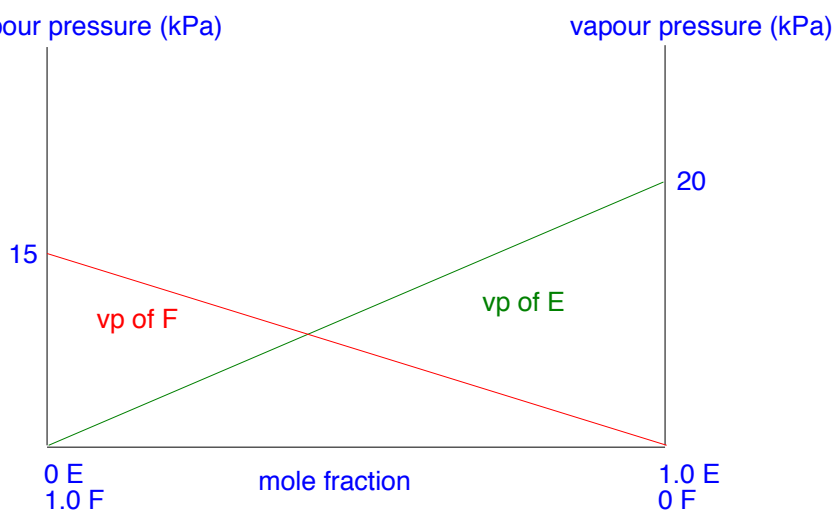
With ethanol and pentane, ethanol has van der Waals dispersion forces, dipole-dipole attractions and hydrogen bonding, but pentane only has dispersion forces. Between ethanol and pentane there can only be dispersion forces (and dipole-induced dipole forces, if you have come across them). The molecules won't have the same tendency to escape from the mixture as from the pure liquids, and so the mixture won't be ideal.

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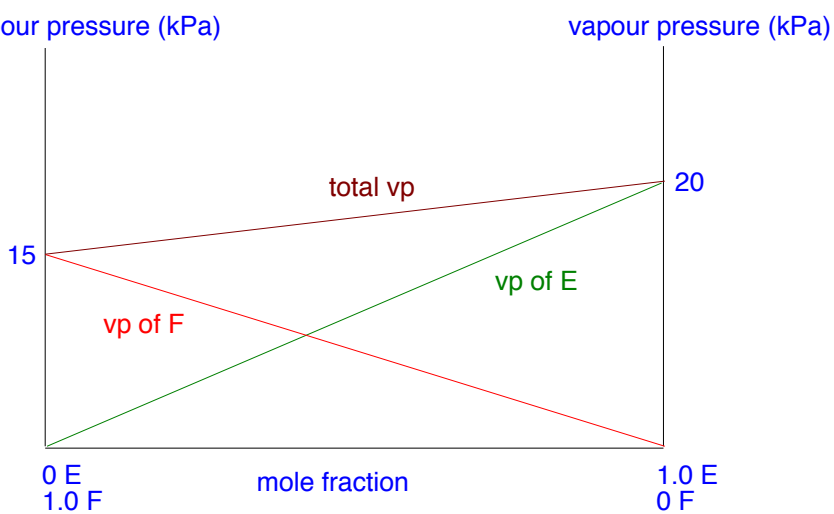
2. a) vapour pressure (kPa)



b) vapour pressure (kPa)



c) vapour pressure (kPa)



d) F has the higher boiling point.

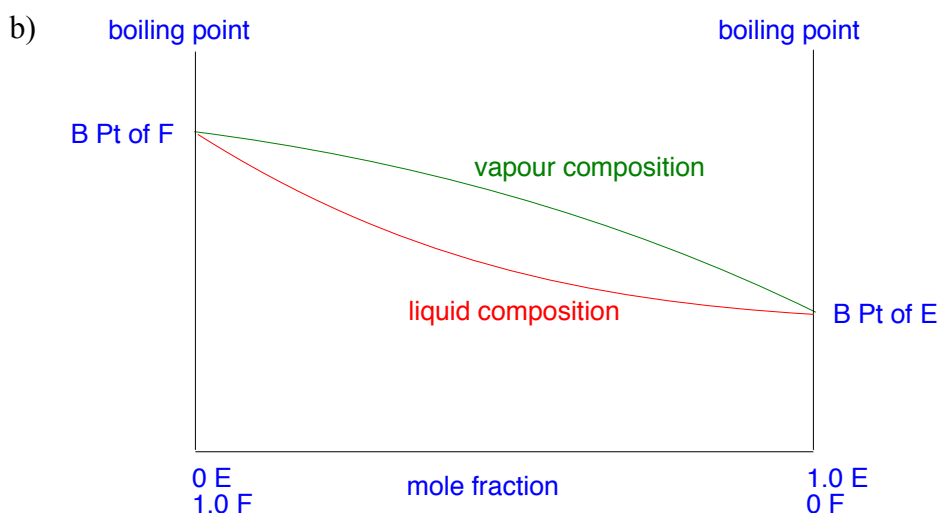
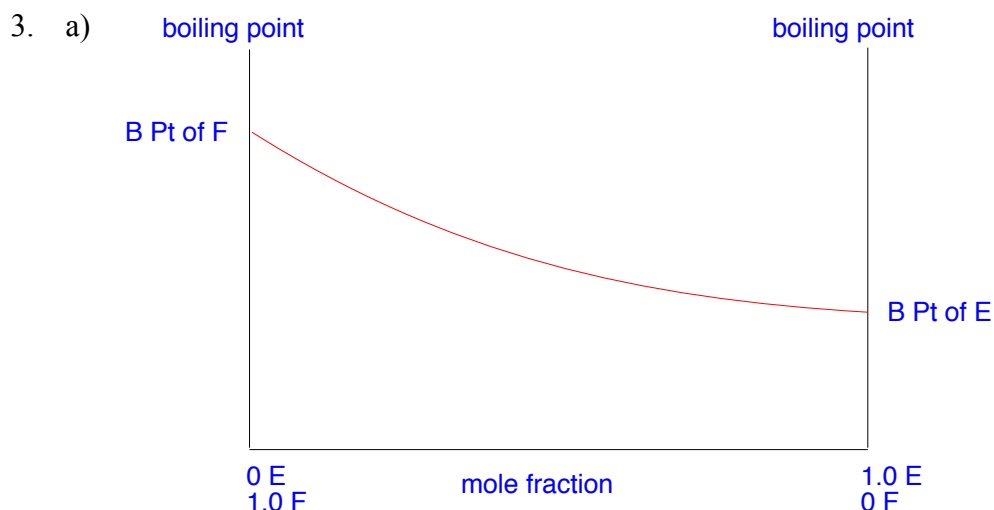
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You need to look at the vapour pressure values for pure E and F. The vapour pressure of pure F is 15 kPa. The vapour pressure of pure E is 20 kPa.

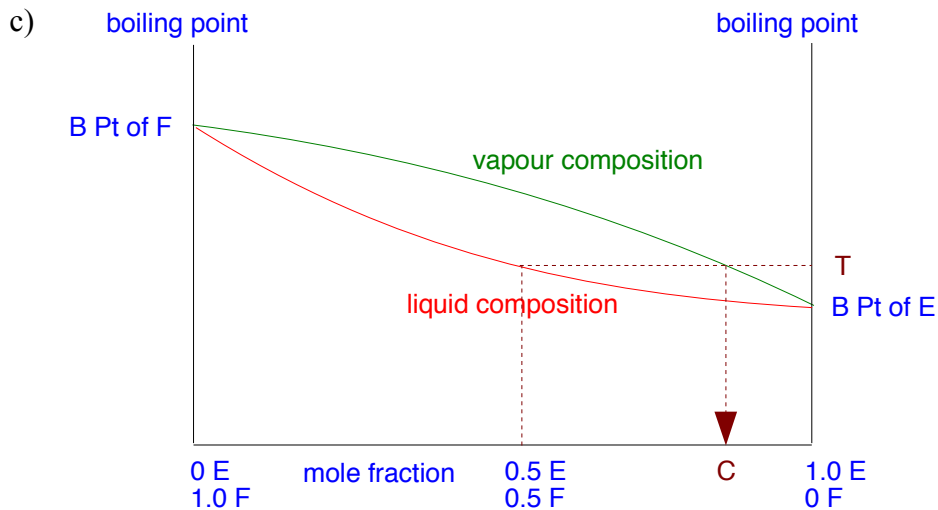
Either: F has a lower vapour pressure, showing that there must be stronger forces between its molecules, and therefore you need to supply more heat to boil it.

Or: A liquid will boil when its vapour pressure is equal to the external pressure. E has the higher vapour pressure, and so will reach that point first, and so F has the higher boiling point.

(Note: I've said this on the main page, but it is worth saying it again. Because the vapour pressures and boiling points of the pure liquids aren't exactly the same, they can't have exactly the same intermolecular forces, and so they can't be ideal. In reality, the total vapour pressure line would be a curve, because the mixture won't obey Raoult's Law exactly. We make this rather faulty simplification during this introduction to the topic to avoid things getting too complicated at the beginning. You will find that this simplification is removed in subsequent Chemguide pages where we look at real, rather than ideal, mixtures.)



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Find the boiling temperature of the mixture from the liquid composition curve (T). Find the vapour composition at that temperature from the vapour composition curve. Your vapour has the composition C, which is much richer in E than the original mixture.

Is that a sensible answer? Yes, you would expect the vapour to be richer in the more volatile component. E has the lower boiling point, and so will be more volatile than F.