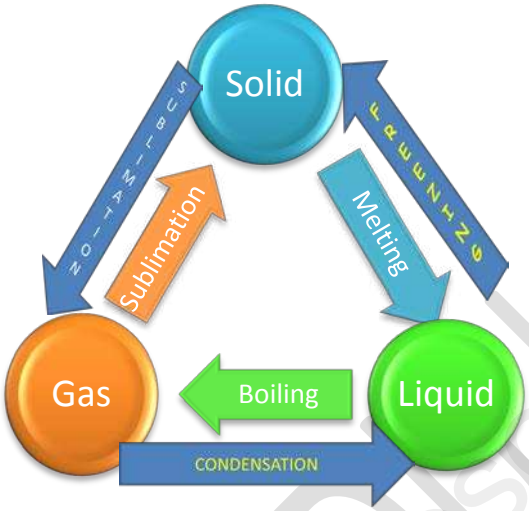
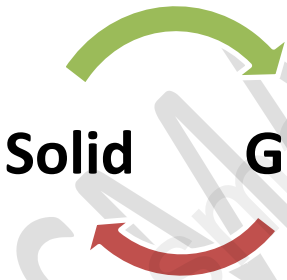
Change of state



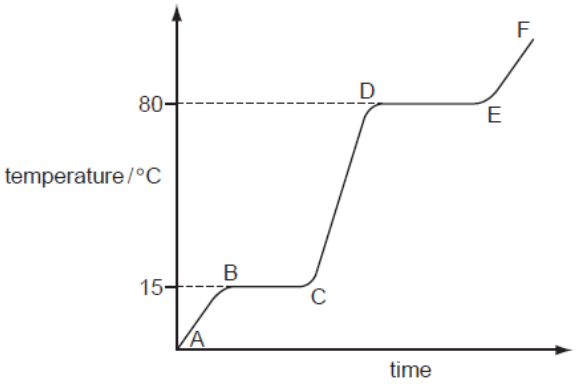
Some substances directly change state from solid to gas or from gas to a solid . This process is called as sublimation.



Examples of substances that sublime are:

- Dry ice (solid carbon dioxide)
- Iodine
- Arsenic
- Naphthalein (The stuff the camphor balls are made of)

Explaining the change of state on the basis of kinetic theory



- Between A -B:The temperature of the solid increases. This is because increasing the heat energy increases the vibration of the particles in the solid.
- Between B-C:The force of attraction between the particles is weakened so the particles are able to slide past over each other. The temperature does not increase as all the heat supplied goes into overcoming the forces between the particles instead of raising the temperature. The substance melts.
- Between C-D. As time progresses the average kinetic energy of the liquid particles increases. Hence the temperature increases.
- Between D-E: The force of attraction between the particles is further weakened, so much so that the particles move well away from each other. The temperature is constant because the energy supplied goes into overcoming the forces between the particles instead of raising the temperature. The substance boils.
- Between E and F:The average kinetic energy of the particles increases and hence the speed of the particles also increases. Hence the temperature increases. The gas particles are now further away from each other.
- Note: In the region BC, The equation of the equilibrium is:

$$\text{Solid} \rightleftharpoons \text{Liquid} \qquad X(s) \rightleftharpoons X(l)$$

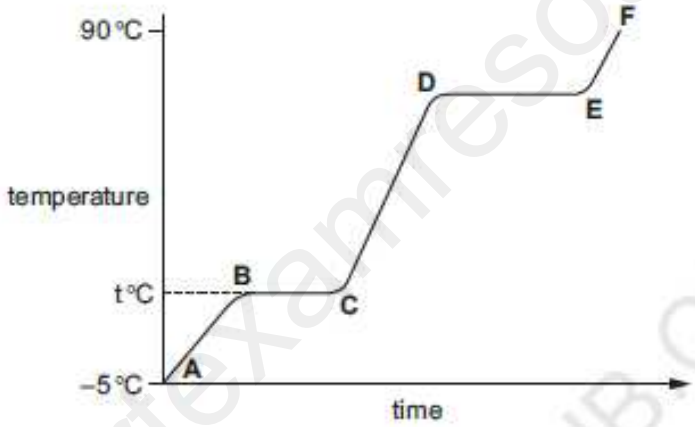
- The graph proves that a pure substance was used as the substance has a sharp melting point (at BC) and a sharp boiling point (at DE.)
- The temperatures 15^0C and 80^0C are important as they represent the melting and the boiling points.
- If an impure sample would have been used, the line BC would have been lower and the line DE would have been higher.

	C TO D	E TO F
Separation between particles	Close and touching	Far apart
Movement of particles	Random and slow	Fast and random
Can the particles move apart to fill the volume	Cannot move apart	Can move apart

[O/N/2014-p33-q2]

2 Compound X is a colourless liquid at room temperature.

(a) A sample of pure X was slowly heated from –5.0 °C, which is below its melting point, to 90 °C, which is above its boiling point. Its temperature is measured every minute and the results are represented on the graph.



(i) Complete the equation for the equilibrium present in the region BC.

X(s) ⇌ ..... [1]

(ii) What is the significance of temperature t °C?

..... [1]

(iii) What is the physical state of compound X in the region EF?

..... [1]

(iv) What would be the difference in the region BC if an impure sample of X had been used?

..... [1]

APPLICATION BASED QUESTIONS WITH MARKING SCHEME-NEW ADDITIONS

MULTIPLE CHOICE QUESTIONS:

1 In which changes do the particles move further apart?

$$\text{gas} \underset{Y}{\overset{W}{\rightleftharpoons}} \text{liquid} \underset{Z}{\overset{X}{\rightleftharpoons}} \text{solid}$$

A W and X **B** W and Z **C** X and Y **D** Y and Z

ANSWER:D

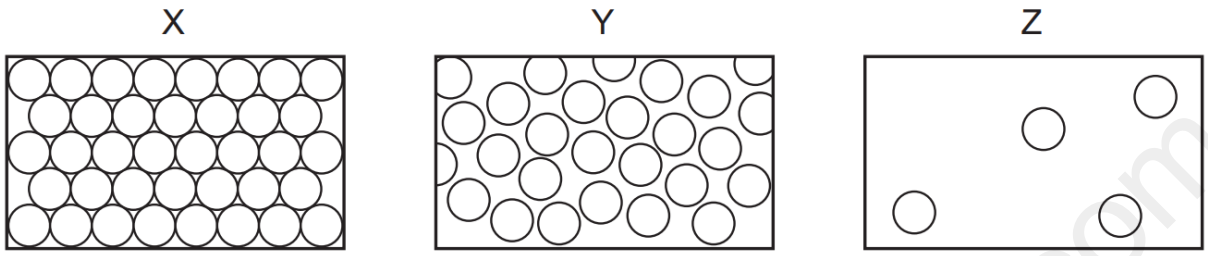
2 What are the processes W, X, Y and Z in the following diagram?

$$\text{solid} \underset{Y}{\overset{W}{\rightleftharpoons}} \text{liquid} \underset{Z}{\overset{X}{\rightleftharpoons}} \text{gas}$$

	W	X	Y	Z
A	condensing	boiling	freezing	melting
B	condensing	freezing	melting	boiling
C	melting	boiling	freezing	condensing
D	melting	freezing	condensing	boiling

ANSWER:C

3 Diagrams X, Y and Z represent the three states of matter.



Which change occurs during boiling?

A X to Y **B** Y to Z **C** Z to X **D** Z to Y

MARKING SCHEME:B

4 Which change of state takes place during evaporation?

A gas to liquid

B liquid to gas

C liquid to solid

D solid to gas

MARKING SCHEME:B

5 In which process do particles move closer together but remain in motion?

A condensation

B diffusion

C evaporation

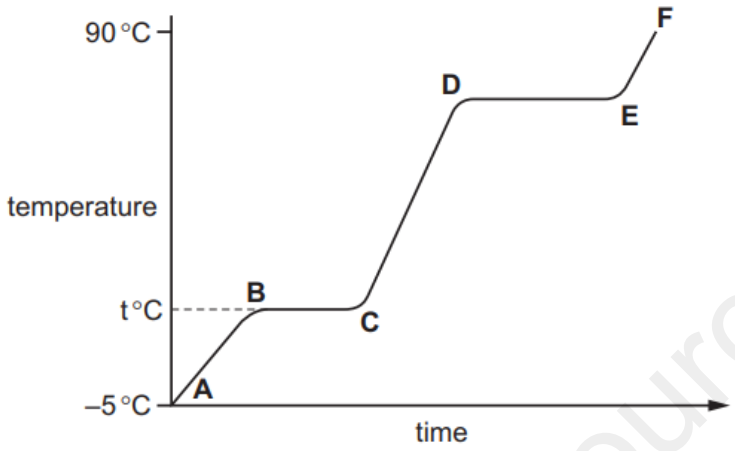
D freezing

MARKING SCHEME: A

EXTENDED THEORY QUESTIONS-NEW ADDITIONS

1 Compound X is a colourless liquid at room temperature.

(a) A sample of pure X was slowly heated from –5.0 °C, which is below its melting point, to 90 °C, which is above its boiling point. Its temperature is measured every minute and the results are represented on the graph.



(i) Complete the equation for the equilibrium present in the region **BC**.

X(s) ⇌ ..... [1]

(ii) What is the significance of temperature t °C?

..... [1]

(iii) What is the physical state of compound X in the region **EF**?

..... [1]

(iv) What would be the difference in the region **BC** if an impure sample of X had been used?

..... [1]

MARKING SCHEME:

(a (i) (X(s) ↔) X(l) [1]

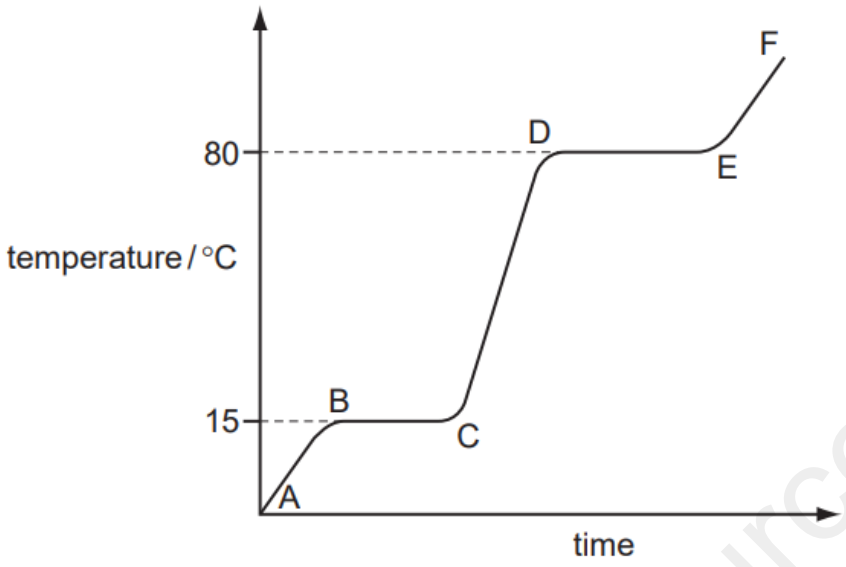
(ii) melting point/freezing point (of X) [1]

(iii) gas/gaseous or vapour [1]

(iv) not horizontal **or** line slopes **or** line is lower [1]

The diagram shows a heating curve for a sample of compound X.

2



(a) Is X a solid, a liquid or a gas at room temperature, 20 °C?

..... [1]

(b) Write an equation for the equilibrium which exists in region BC.

..... [2]

(c) Name the change of state which occurs in region DE.

..... [1]

(d) Explain how the curve shows that a pure sample of compound X was used.

.....

MARKING SCHEME:

(a liquid; [1]

(b) (l) and (s); [1]
reversible sign; [1]
accept: X in equation
ignore: any compounds just look for state symbols
must be the same compound on both sides of equation

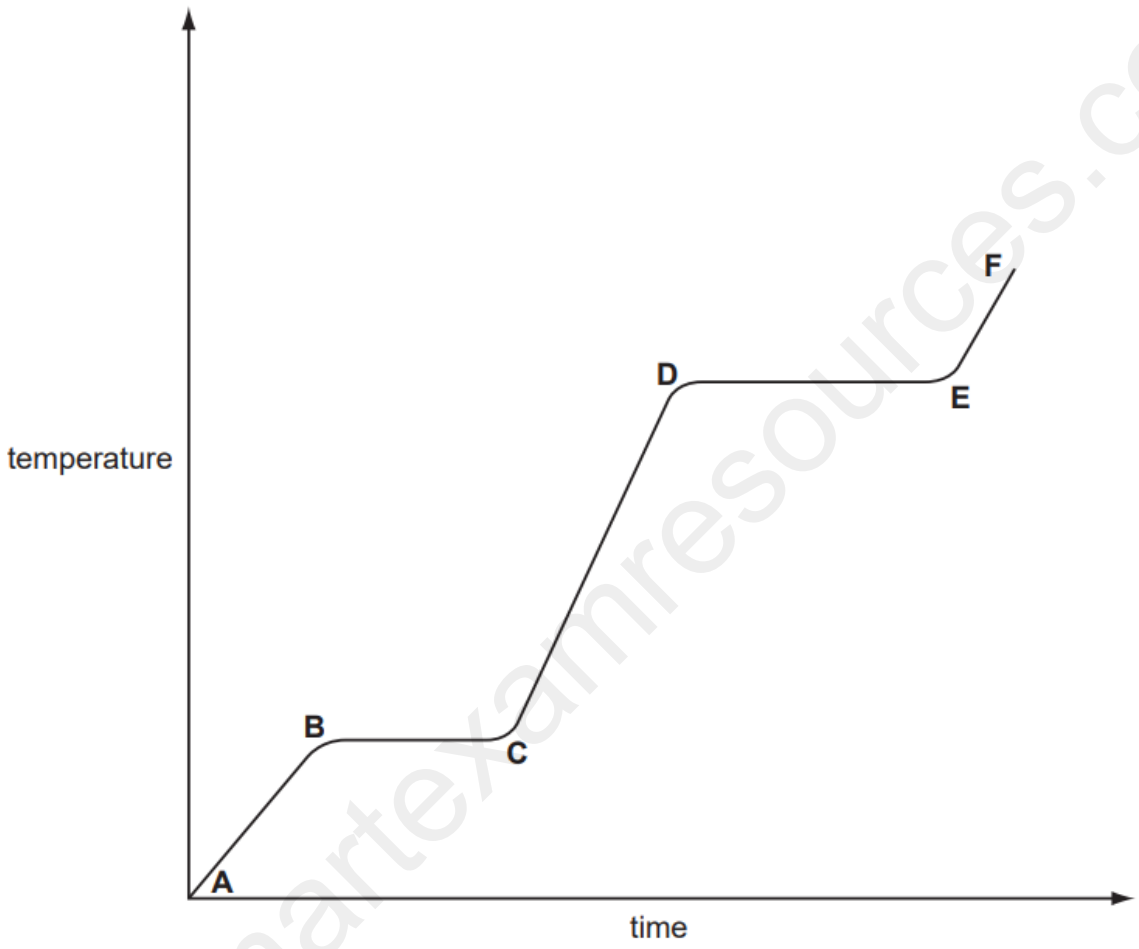
(c) boiling / condensation; [1]
accept: evaporation or vaporisation

(d) (in region BC) solid melts / liquid boils (in region DE); [1]
at one / fixed / sharp / single / specific temperature; [1]

[Total: 6]

3 Ethanoic acid is a colourless liquid at room temperature. It has the typical acid properties and forms compounds called ethanoates.

(a) A pure sample of ethanoic acid is slowly heated from 0°C to 150°C and its temperature is measured every minute. The results are represented on the graph below.



(i) Name the change that occurs in the region **D** to **E**.

..... [1]

(ii) What would be the difference in the region **B** to **C** if an impure sample had been used?

..... [1]

(iii) Sketch on the graph how the line would continue if the acid was heated to a higher temperature. [1]

(iv) Complete the following table that compares the separation and movement of the molecules in regions **C** to **D** with those in **E** to **F**.

	C to **D**	**E** to **F**
separation (distance between particles)	.....	.....
movement of particles	random and slow	....
Can particles move apart to fill any volume?	.....	.....

[5]

MARKING SCHEME:

5 **(a)(i)**	boiling		**[1]**
(ii)	lower temperature **or** over temperature range or no plateau		**[1]**
(iii)	direct continuation of E to F		**[1]**
(iv)	close **or** touching	far apart	**[2]**
		fast and random	**[1]**
	cannot move apart	can move apart	**[2]**