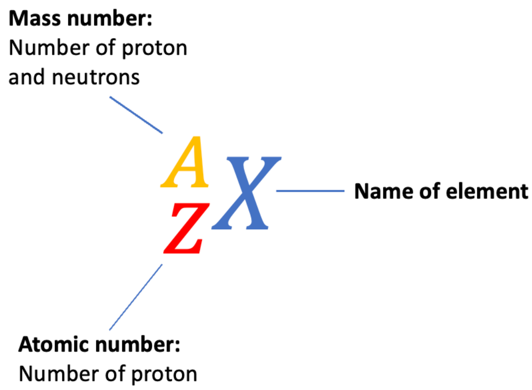
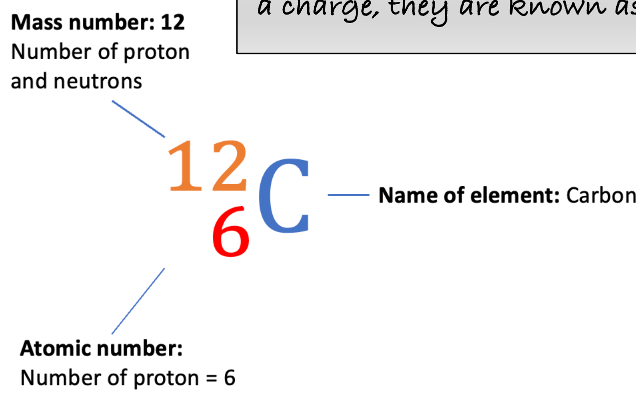
IB Physics Topic 3 Revision Guide

Atom

- Atomic number = proton number
- Electron number = Proton number for an atom
- Neutron number = mass number- proton number

> **Note:** For all atoms, electron number = proton number since they are neutral. For an atom with a charge, they are known as ions.





Ideal Gas

- The molecules are point particles, each with negligible volume
- The molecules obey the laws of mechanics.
- There are intermolecular forces except when molecules collide
- Molecules have a range of speeds and move randomly.
- Collisions between molecules the walls are elastic.
- The duration of a collision is negligible compared to the time between collisions.

> **Important to know:**
> - Real gas can be approximated into ideal gas at high temperature and low pressure
> - Real gas maintains the opposite description of an ideal gas

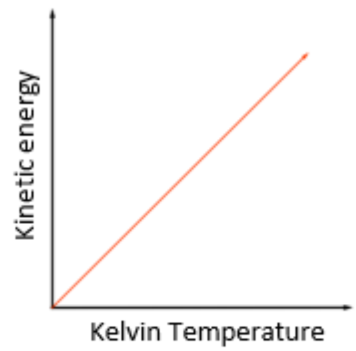
State of Matters

	Solids	Liquids	Gases
Distance between particles	close together	close but further apart than in solids	particles far apart
Arrangement	regular	random	random
Shape	fixed shape	no fixed shape	no fixed shape
Volume	fixed	fixed	not fixed
Movement	vibrate	move around	move in all directions
Speed of movement	slowest	faster	fastest
Potential Energy	lowest	higher	highest
Forces of attraction	strongest	weaker	weakest

> **Important to Know**
> - Potential energy at gaseous state > liquid state > solid state because distances between atoms are farther in at gaseous state > liquid state > solid state.

Temperature and Kinetic Energy

- Temperature is directly proportional to kinetic energy as shown by the figure.
- Matters at the same temperature have the same kinetic energy regardless of the state (solid, gas, or liquid)
- The lowest kinetic energy is zero (at test) at zero Kelvin, which is known as the absolute zero.



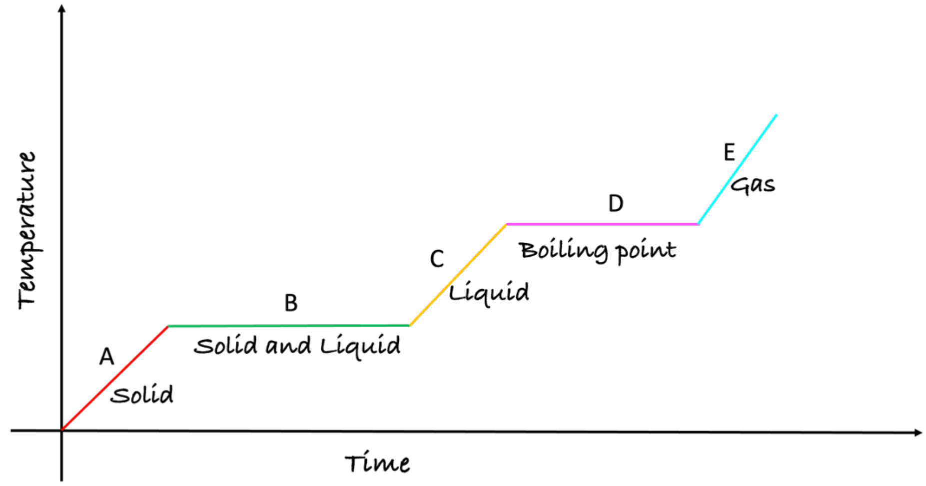
One IB Question

Molecules leave a boiling liquid to form a vapour. The vapour and the liquid have the same temperature. What is the change of the average potential energy and the change of the average random kinetic energy of these molecules when they move from the liquid to the vapour?

	Average potential energy	Average random kinetic energy
A.	increases	increases
B.	increases	no change
C.	no change	increases
D.	no change	no change

The correct answer is B. Since molecules are at the same temperature, they must have the same amount of kinetic energy. A Vapour state has more potential energy because atoms are farther away from each than atoms in the liquid form.

Heating Curve



- In B and D, kinetic energy remains constant since temperature is constant, and heat energy breaks intermolecular forces.

$$Q = mL$$

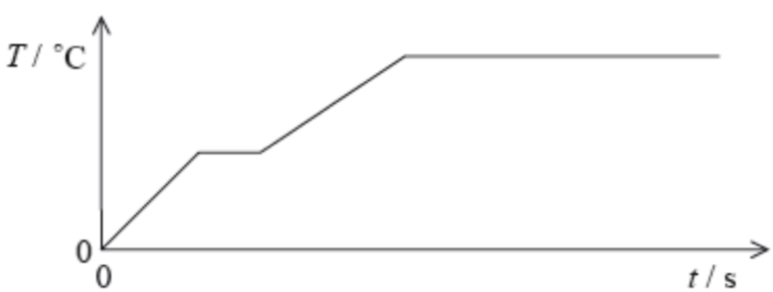
  - latent heat (L) is the energy absorbed or released during a change in its physical state without changing its temperature
- In A, C, and E, kinetic energy increases since temperature, and potential energy increases since atoms are farther away from each other.

$$Q = cm\Delta T$$

  - The specific heat capacity of a substance is the amount of energy required to raise the temperature of 1 kg of the substance by 1°C.

How is it tested in IB?

Graphical Problem



When seeing a graph, think about **gradient** and area under the curve.

- Energy at constant/uniform rate→power is a constant

$$P = \frac{Q}{\Delta t} = cm\frac{\Delta T}{\Delta t}$$

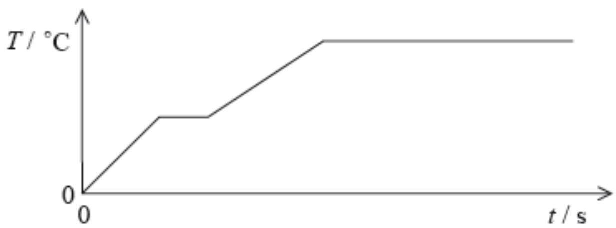
$$P_L = \frac{Q}{\Delta t} = m\frac{L}{\Delta t}$$

Important to know

- At constant power, greater gradient means a smaller specific heat capacity, and a longer time means a larger latent heat capacity.

Some IB Questions

1. Thermal energy is added at a constant rate to a substance which is solid at time . The graph shows the variation with of the temperature .



Thermal energy is added at a constant rate means a constant power.

$$P = \frac{Q}{\Delta t} = cm\frac{\Delta T}{\Delta t} = \text{constant}$$

$$P_L = \frac{Q}{\Delta t} = m\frac{L}{\Delta t} = \text{constant}$$

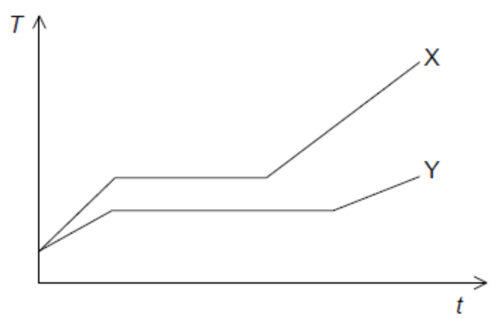
Which of the statements are correct?

I. The specific latent heat of fusion is greater than the specific latent heat of vaporization.
II. The specific heat capacity of the solid is less than the specific heat capacity of the liquid.

A. I only
B. I and II
C. II only
D. Neither I nor II

The correct answer is C. Latent heat at solid and liquid has a shorter time and, therefore, greater latent heat capacity. Solid state has a larger gradient, therefore, smaller specific heat capacity.

2. The graph shows the variation with time *t* of the temperature *T* of two samples, X and Y. X and Y have the same mass and are initially in the solid phase. Thermal energy is being provided to X and Y at the same constant rate.



Constant rate means constant power. Y has a longer time for latent heat than X, but X as a steeper slope for specific heat than Y.

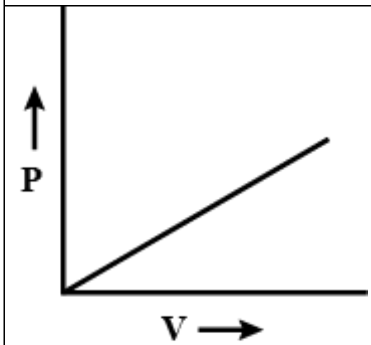
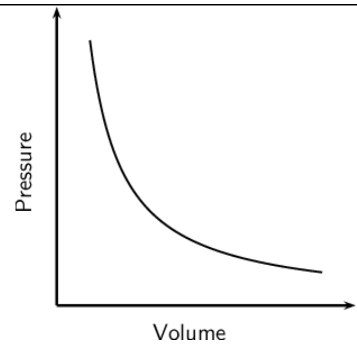
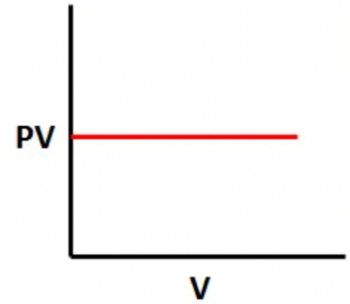
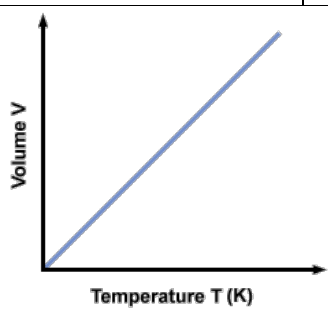
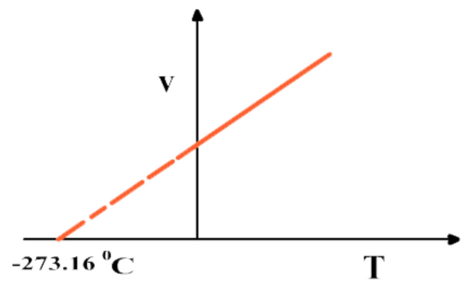
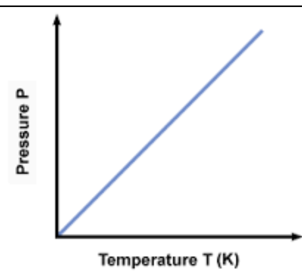
$$P = \frac{Q}{\Delta t} = cm\frac{\Delta T}{\Delta t} = \text{constant}$$

$$P_L = \frac{Q}{\Delta t} = m\frac{L}{\Delta t} = \text{constant}$$

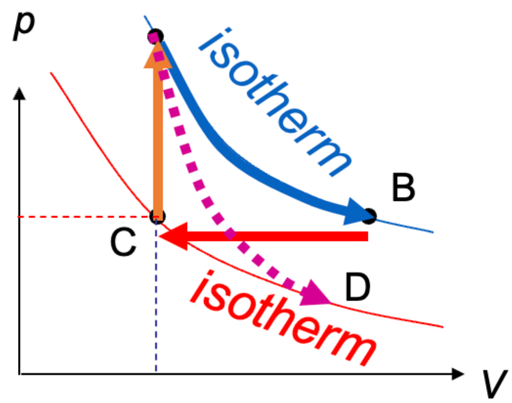
What is the correct comparison of the specific latent heats L_X and L_Y and specific heat capacities in the liquid phase c_X and c_Y of X and Y?

A.	$L_X > L_Y$	$c_X > c_Y$
B.	$L_X > L_Y$	$c_X < c_Y$
C.	$L_X < L_Y$	$c_X > c_Y$
D.	$L_X < L_Y$	$c_X < c_Y$

The correct answer is D. Since Y has a long time for latent heat and mass is fixed, it must have a larger latent heat capacity for power to be a constant. Since the gradient for X is steeper (larger), the value of specific heat capacity must be smaller than Y for the power to be constant.

The Pressure–Volume law (Boyle's law)		
At constant temperature and with a fixed quantity of gas, pressure is inversely proportional to volume		
$p \propto \frac{1}{V}$	$pV = constant$	$p_1V_1 = p_2V_2$
		
The volume–temperature law (Charles' law)		
When the temperature is in kelvin, this experiment implies that at constant pressure:		
$\frac{V}{T} = constant$	$V \propto T$	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$
		
Gay-Lussac's law		
When the temperature is in kelvin, this experiment implies that at constant volume:		
$\frac{p}{T} = constant$	$p \propto T$	$\frac{p_1}{T_1} = \frac{p_2}{T_2}$
		
Ideal Gas Equation		
$\frac{pV}{T} = constant$	$\frac{pV}{T} = n \times constant$	$pV = nRT$

- Isobaric Process: Pressure is constant
- Isothermal Process: Temperature is constant
- Isochoric Process: Volume is constant



Important to know

- **Expansion**: Positive work done by the system, volume increase
- **Compression**: Negative work done by the system, volume decreases