Thermal Physics

IB Physics Content Guide

Big Ideas

- The macroscopic effects of volume, pressure, and temperature can be understood with a microscopic model
- Kinetic Energy on a molecular level is observed as temperature and heat
- The heat required to change the temperature or phase of a material is a property of the material itself
- The properties of an ideal gas are proportional to each other and can be calculated under certain conditions

1 – Heat vs Temperature

I can explain the relationship between temperature and molecular kinetic energy			
I can describe the energies present in an object's total internal energy			
I can convert between Celsius and Kelvin			
I can describe the nature of molecules when at a temperature of absolute zero			
I can compare temperature (average KE) and heat (total KE)			
I can relate average molecular kinetic energy with absolute temperature			
I can calculate the average molecule speed for a molecule at a certain temperature			
I can describe the molecular process that allows heat to flow			

2 – Specific Heat Capacity

I can define specific heat capacity with proper units			
I can describe the effect of larger or smaller specific heat values			
I can relate specific heat capacity to the heat energy and temperature change			
I can describe how a calorimeter uses the conservation of heat to study a material's specific heat			
I can experimentally determine the specific heat capacity of a material			

3 – Specific Latent Heat

I can identify key features in a material's heating curve			
I can describe why a heating curve plateaus during phase changes			
I can describe the different ways that the heat added to a system can become internal energy			
I can define specific latent heat with proper units			
I can calculate the heat required to cause a certain amount of a substance to change phases			
I can compare the processes of evaporation and boiling			

4 – Conduction, Convection, and Radiation

I can define the thermal transfer processes of conduction, convection, and radiation			
I can quantify and calculate thermal conductivity			
I can describe convection in terms of fluid density differences			

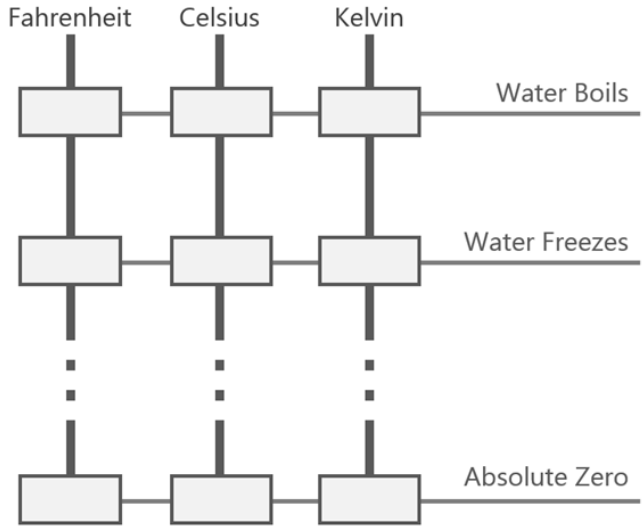
5 – Gas Properties

I can define pressure with appropriate fundamental and derived units			
I can describe the importance of having a large quantity like the "mole" defined			
I can use the average atomic weight of an element to convert between mass and moles			

6 – Gas Laws

I can describe the conditions necessary for a substance to be considered an ideal gas			
I can describe the relationship between volume, pressure, and temperature for an ideal gas			
I can describe changes in pressure in terms of kinetic molecular theory			
I can use the Ideal Gas Law to solve for pressure, volume, amount, or temperature			
I can use the Ideal Gas Law to describe how changing one or more variable(s) affects another			
I can calculate the total internal energy for an ideal gas			

Temperature



Temperature Conversion:

$$\text{Temperature (K)} = \text{Temperature (°C)} + 273$$

Conditions for Absolute Zero:

Kinetic Theory and Temperature

$$\bar{E}_K = \frac{3}{2} k_B T$$

$$k_B = 1.38 \times 10^{-23}\,\text{J K}^{-1}$$

Variable Symbol	Description	Unit
$\bar{E}_K$		
k_b		
T		

Internal Energy

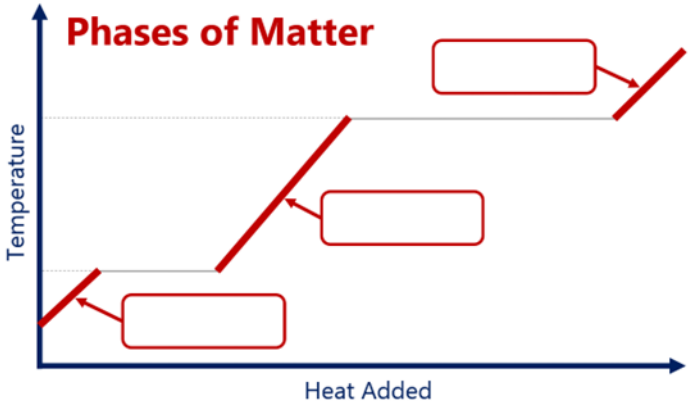
$$U = E_K + E_P$$

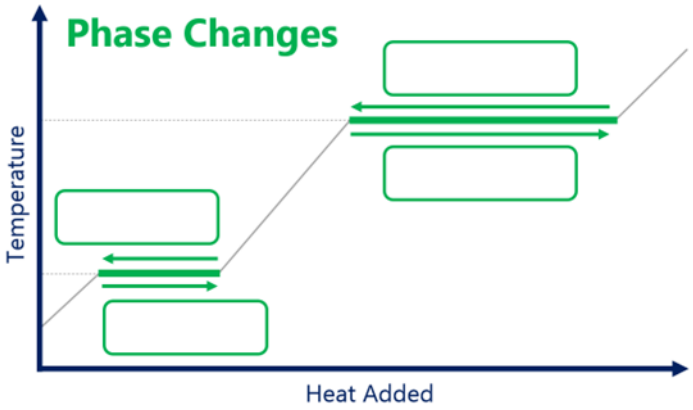
U	
E_K	
E_P	

Specific Heat Capacity and Specific Latent Heat

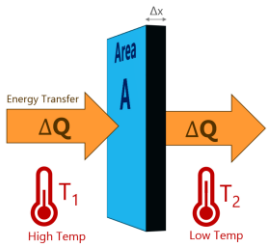
	Variable Symbol	Description	Unit
$Q = mc\Delta T$ $Q = mL$	Q		
	m		
	c		
	ΔT		
	L		

Heating Curves





Thermal Conduction

	Variable Symbol	Description	Unit
$\frac{\Delta Q}{\Delta t} = -kA\frac{\Delta T}{\Delta x}$ 	ΔQ		
	Δt		
	$\frac{\Delta Q}{\Delta t}$		
	k		
	A		
	ΔT		
	Δx		

Thermal Energy Transfer

Conduction	Convection	Radiation

Pressure

	Variable Symbol	Description	Unit	
$P = \frac{F}{A}$	P			
	F			
	A			

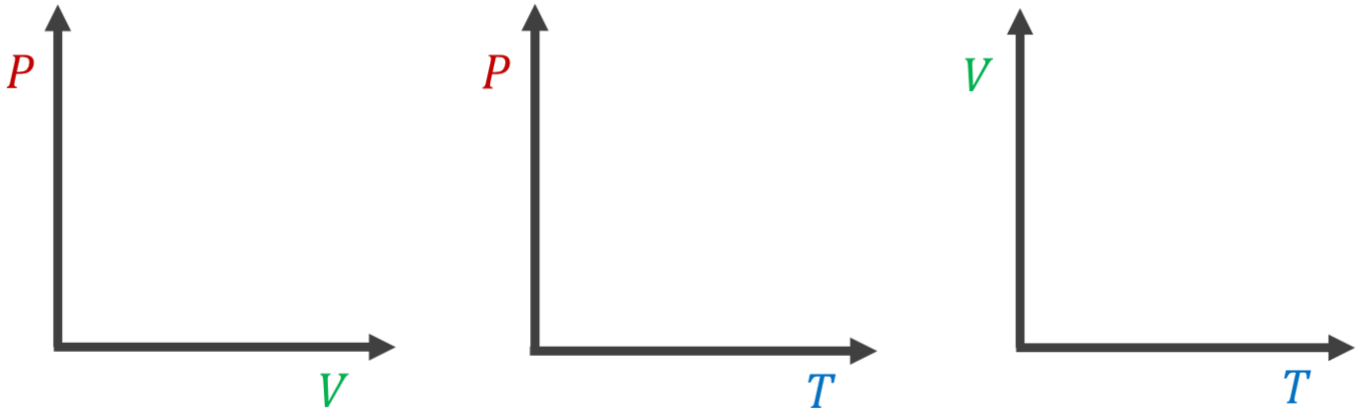
Atmospheric Pressure		

The Mole

	Variable Symbol	Description	Unit
$n = \frac{N}{N_A}$	n		
	N		
$N_A = 6.02 \times 10^{23}$	N_A		

Ideal Gas Assumptions

Ideal Gas Relationships



Ideal Gas Equations

$$PV = nRT$$
$$PV = Nk_BT$$
$$U = \frac{3}{2}nRT = \frac{3}{2}Nk_BT$$
$$k_B = 1.38 \times 10^{-23}\ \text{J K}^{-1}$$
$$R = 8.31\ \text{J K}^{-1}\text{mol}^{-1}$$

Variable Symbol	Description	Unit
P		
V		
n		
R		
T		
N		
k_B		
U		

$$P = \frac{1}{3}\rho v^2$$

Variable Symbol	Description	Unit
P		
ρ		
v		