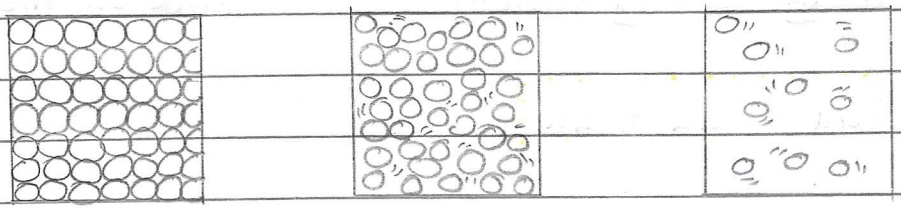
21 - Thermal Physics

Q-1) Change of state.



solid liquid gas

> During a change of state, [solid -> liquid -> gas], the distance between the molecules increases. As the seperation increases, their potential energy increases. * There is no change in temperature, hence no change in k.e. as the energy supplied is used for breaking the bonds.

* Melting and Boiling take place with no change of temperature.

Q-2) Evaporation.

> When a liquid changes to a gas without boiling, it is called evaporation.

> Within a liquid, the molecules are moving about. When a liquid evaporates, its the most energetic molecules that are most likely to escape.

> Since temperature is a measure of the average k.e of the molecules, the temperature of the liquid falls since the average k.e has reduced.

Q-3) What is internal energy?

> The internal energy of a system is the sum of the random distribution of kinetic and potential energies of its atoms or molecules.

* For an ideal gas, IE depends only on k.e as intermolecular forces are negligible ∴ PE is zero.

Q-4) First law of thermodynamics

> increase in internal energy = energy supplied by heating + energy supplied by doing work on the gas.

$$du = dQ + dW$$

Q-5) What are isothermal and adiabatic changes?

* Isothermal change.

Change in pressure and volume at a constant temperature. $du = 0$.

* Adiabatic change.

change in pressure, volume and temperature without any thermal energy entering or leaving the system. $dQ = 0$.

Q-6) What is thermal energy?

> Energy flowing from a region of higher temperature to a region of lower temperature is called thermal energy.

* When 2 objects, in contact with each other, are at the same temperature, there is no net transfer of thermal energy between them. They are in thermal equilibrium.

Q-7) Thermodynamic scale and thermometers.

> Thermodynamic scale is the Kelvin.

$0K = -273.15^{\circ}C$

* It has 2 fixed points

lower: absolute 0 zero

upper: triple point of water (273.16K)

↳ H_2O (g)(l)(s) co-exist.

Resistance thermometer ↳ thermistor	Thermocouple.
Very robust	robust
narrow range	wide range
Large size, great thermal capacity, ∴ Slow acting	small size, small thermal capacity, ∴ fast acting measures temperature at a point.
high sensitivity over narrow range.	can be sensitive with appropriate metals chosen.
Fairly linear over narrow range; no callibration needed.	non-linear; requires callibration
self heating depends on property of a substance.	no self heating; self powered doesn't depend on property of a substance

Q-8) What is specific heat capacity?

> It's the energy required per unit mass of the substance to raise its temperature by 1K.

$$E = mc\Delta\theta$$

$$VIt = mc\Delta\theta$$

Determining c

* Supply a known amount of energy to a known mass of the material and measure the temperature change with time.

* Errors:
  - heat is lost to surroundings
    ↳ insulation.
  - heat doesn't spread throughout the material
    ↳ low rate of heating.

Q-9) What is specific latent heat?

> It's the energy required per kilogram of the substance to change its state without change in temperature.

Latent heat of fusion (L_f): solid -> liquid (melting)
Latent heat of vapourisation (L_v): liquid -> gas (boiling)

$$E = mL$$
$$VIt = mL$$

Determining L

* Supply a known amount of energy. Record the change in mass with time.

Errors:
- heat is lost to surroundings.
  L_f : under-estimate of value (heat is absorbed)
  L_v : over-estimate of value. (heat is lost)

L_f/L_v : It's the energy required to convert 1kg of a solid/liquid to a liquid/gas without any change in temperature.

Q-10) Why is latent heat of vapourisation ⇒ greater than latent heat of fusion?

> When a solid melts, the molecules are still bonded to most of its neighbouring molecules.
When a liquid boils, each molecule breaks free of all of its neighbouring molecules.

> Melting involves breaking of a few bonds.
Boiling involves breaking of a large no. of bonds.

OR > $du = dQ + dw$ -- dw is -ve as its expansion.

$\therefore dQ = \underbrace{du + dw}$.
is greater in Lv.

$\therefore Lv > Lf$.

Q-11) Work done on/by a gas?

> Work done = pressure x change in volume

$WD = p \Delta V$