Lesson 13:4
(Please listen to the explanations and fill in the blanks. The enclosed 5 questions will be discussed in the class)

6. Internal energy U

1. **Internal energy** is the ______of a ___________distribution of ___________energy and ___________energy associated with ____the molecules of a system. $U = \sum (KE + PE)$

2. KE of molecules is related to the absolute temperature.
3. PE of molecules depends on intermolecular bonds which hold the molecules together and the separation between molecules.

4. In an ideal gas, NO __________________________ exists between molecules.
   PE = ____ and the internal energy is the sum of KE only.
   Since $\langle KE \rangle \propto T$, internal energy of ideal gas depends on temperature only.

5. The change of internal energy of a substance depends only on the initial and final states of the substance and not in any way by the path or manner of the change.
   $$\Delta U = U_2 - U_1$$
   where U_1 and U_2 are intrinsic energy of the system at initial and final states, respectively.

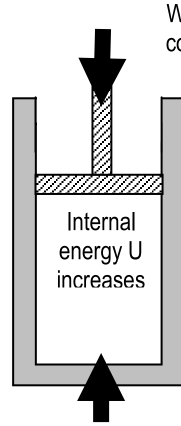
6. When a substance undergoes some changes and eventually goes back to the initial state, there is no change in its internal energy, i.e. $\Delta U = 0$.

7. The First Law of Thermodynamics

1. $dU = Q + W$

   The _________ in internal energy U of molecules in system is equal to the heat Q ________to it and the work done W ___ it.

2. It is based on the law of Conservation of ___________________ which states that ____
____



Whatever actions that increase the internal energy of the system are given +ve signs and the reverse, –ve signs.

	+ve	–ve
ΔU	increase in internal energy	decrease in internal energy
Q	Heat supplied to the system	heat extracted from the system
W	work done on the system	work done by the system (expansion)

Questions on the 1st Law of Thermodynamics

1. An ideal gas does 500 J of work in an adiabatic state, i.e. no heat energy supplied or lost.
   a) Deduce the change in the internal energy of the gas.
   b) Deduce about the temperature of the gas.

2. A sample of gas is enclosed in a cylinder by a frictionless piston of area 60 cm^2. The cylinder is heated so that 400 J of heat energy is supplied to the gas which then expands against atmosphere pressure and pushes the piston 20 cm along the cylinder. Given that atmospheric pressure is $1.0x10^5$ Pa, calculate:
   c. the external work done by the gas [120J]
   d. the change in internal energy of the gas. [280J]

3. When 0.60 kg of water is converted into steam at l0 °C at a pressure of $1.0x10^5$ Pa, the amount of heat energy supplied is 2.9×10^6 J. If during the vaporisation the water increases its volume by 2.2 m^3, calculate:
   e. the work done against the external pressure [220kJ]
   f. the increase in the internal energy of the water. [2.7e6J]

4. Given:
   - density of water at 100 °C = 960 kgm^{-3}
   - density of steam at 100 °C and at atmospheric pressure = 0.59 kgm^{-3}
   - atmospheric pressure, Po = 1.01 x 10^5 Pa
   - specific latent heat of vaporisation = 2.26 x 10^6 J kg^{-1}

Using the data given above, calculate the increase in internal energy when 1.00 kg of water at 100 °C changes to steam at atmospheric pressure. [ans: 20.9 x 10^5 J]

Solution:
Energy supplied $Q = ml_v$
Work done in expansion $W = p\,\Delta V$
1st Law : $dU = Q + W$

5. (a) What is meant, in molecular terms, by the *internal energy* of a gas?
   ……
   …… [2]

   (b) State qualitatively and explain in molecular terms, what happens to the internal energy of a fixed mass of an ideal gas when, separately,

   (i) the temperature of the gas is raised,
   ……
   ……
   ……

   (ii) the volume is decreased at constant temperature,
   ……
   ……
   ……

   (iii) the gas as a whole is moving at a certain speed.
   ……
   ……
   …… [8]