Internal Energy Chemistry Questions with Solutions

Q-1: The internal energy is the heat evolved or absorbed at
a) Constant pressure
b) Constant volume
c) Constant temperature
d) Constant moles

Answer: b) Constant volume
Explanation: The heat that is emitted or absorbed at a constant volume is the internal energy.

Q-2: The internal energy always has a
a) Indefinite value
b) Definite value
c) Both of the above
d) Can't be predicted

Answer: b) Definite value
Explanation: The internal energy of a definite amount of a particular substance under given conditions of temperature and pressure always has a definite value.

Q-3: Why we cannot determine the exact or absolute value of internal energy?
Answer: It is impossible to determine an object's internal energy in its exact or absolute form. This is because most of the quantities that contribute to the system's internal energy are impossible to estimate with accuracy.

Q-4: Which law explained how internal energy, heat, and work relate to one another?
a) Zeroth Law of Thermodynamics
b) Second Law of Thermodynamics
c) Third law of thermodynamics
d) First law of thermodynamics

Answer: d) First law of thermodynamics
Explanation: According to the first law of thermodynamics, $\Delta E = q + w$
Where q is either heat absorbed or given out by the system.
W is the work done on or by the system.

Q-5: Calculate the internal energy change in each of the following cases: -
(i) A system absorbs 25 kJ of heat and does 15 kJ of work.
ii) 15 kJ of work is done on the system and 25 kJ of heat is given out by the system.

Answer:
(i) Here, q= +25 kJ and w= -15 kJ
According to the first law of thermodynamics,
ΔE = q + w = +25 -15 = 10 kJ
This implies the internal energy of the system increases by 10 kJ.

ii) Here, q= -25 kJ and w= +15 kJ
According to the first law of thermodynamics,
ΔE = q + w = -25 +15 = -10 kJ
This implies the internal energy of the system decreases by 10 kJ.

Q-6: Internal energy is
a) partly potential and partly kinetic
b) totally kinetic
c) totally potential
d) none of these

Answer: a) partly potential and partly kinetic

Q-7: Internal energy(ΔE) is equal to the heat supplied(q) in
a) Adiabatic change
b) Isochoric change
c) Isothermal reversible change
d) Isothermal irreversible change

Answer: b) Isochoric change
Explanation: For Isochoric change, ΔV=0
w= PΔV = 0
Since, ΔE = q + w
This implies, ΔE = q

Q-8: A chemist while studying the properties of gaseous CCl_2F_2, a chlorofluorocarbon refrigerant cooled a 1.25 g sample at constant atmospheric pressure of 1.0 atm from 320 K to 293 K. During cooling, the sample volume decreased from 274 to 248 mL. Calculate ΔE for the chlorofluorocarbon for this process. For CCl_2F_2, C_p= 80.7 J/(mol K).

Answer: $\Delta H = q_p$ and C_p is the heat evolved or absorbed per mole of 1° fall or rise in temperature.
Here, fall in temperature = 320-293 = 27 K.
Molar mass of CCl_2F_2 = 121 g/mol

Therefore, heat evolved from 1.25 g of the sample on being cooled from 320 K to 293 K at constant pressure =(80.7/121) × 1.25 × 27 J = 22.51 J.

Further $\Delta H = \Delta U + P\Delta V = -22.51$ J
$P\Delta V = 1$ atm $\times [(248-274)/1000]$ L $= -0.026$ L atm $= -0.026 \times 101.35$ J $= -2.63$ J
Therefore, $-22.51 = \Delta U + (-2.63)$
$\Delta U = -19.88$ J

Q-9: Calculate the standard internal energy change for the reaction $OF_2(g) + H_2O(g) \rightarrow O_2(g) + 2HF(g)$ at 298 K, given that the enthalpies of formation of $OF_2(g)$, $H_2O(g)$ and $HF(g)$ are +20, -250 and -270 kJ/mol respectively.

Answer:
Step I. Calculation of standard enthalpy of reaction.
$\Delta H_f^o = \sum \Delta H_f^o(\text{products}) - \sum \Delta H_f^o(\text{reactants})$
$\Delta H_f^o = [\Delta H_f^o(O_2) + 2\Delta H_f^o(HF)] - [\Delta H_f^o(OF_2) + \Delta H_f^o(H_2O)]$
$\Delta H_f^o = [0 + 2(-270)] - [+20 + (-250)]$ kJ/mol
$\Delta H_f^o = -310$ kJ/mol

Step II. Calculation of standard internal energy change.

For the given reaction,
$\Delta n_g = (1+2) - (1+1) = 1$
$\Delta H^o = \Delta U^o + \Delta n_g RT$
Or $\Delta U^o = \Delta H^o - \Delta n_g RT$

$\Delta U^o = -310 - [(1) \times (8.314 \times 10^{-3}\ kJK^{-1}mol^{-1}) \times (298\ K)]$
$\Delta U^o = -312.48\ kJmol^{-1}$

Q-10: For which of the following reactions $\Delta H = \Delta U$?
a) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
b) $PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$
c) $H_2(g) + I_2(g) \rightarrow 2HI(g)$
d) $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

Answer: c) $H_2(g) + I_2(g) \rightarrow 2HI(g)$
Explanation: As we know that, $\Delta H = \Delta U + \Delta n_g RT$
Where Δn_g denotes the stoichiometric difference between the gaseous products and the gaseous reactants.

Chemical Reactions	Δn_g

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g$	2-4 = -2
$PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$	1-2 = -1
$H_2(g) + I_2(g) \rightarrow 2HI(g)$	2-2 = 0
$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$	3-0 = 3

Hence for reaction c) ΔH = ΔU as $\Delta n_g = 0$.

Q-11: In an isochoric process, the increase in internal energy is
a) Equal to the heat absorbed.
b) Equal to the heat evolved.
c) Equal to the work done.
d) Equal to the sum of the heat absorbed and work done.

Answer: a) Equal to the heat absorbed.
Explanation: For isochoric processes, ΔV = 0, so $q_V = \Delta E$ i.e, heat given to a system under constant volume is used up in increasing ΔE.

Q-12: For the reaction of one mole of HCl with zinc dust in a bomb calorimeter, how does ΔU and ΔW corresponds?

Answer: The bomb calorimeter, which consists of a sealed combustion chamber known as a bomb, is frequently used to measure the heat of combustion of organic substances. No expansion or compression is allowed during a procedure if the container is sealed. so W=0 and ΔU = q.

Q-13: For isothermal expansion, which is true?
a) ΔV = 0
b) ΔA = 0
c) ΔG = 0
d) ΔU = 0

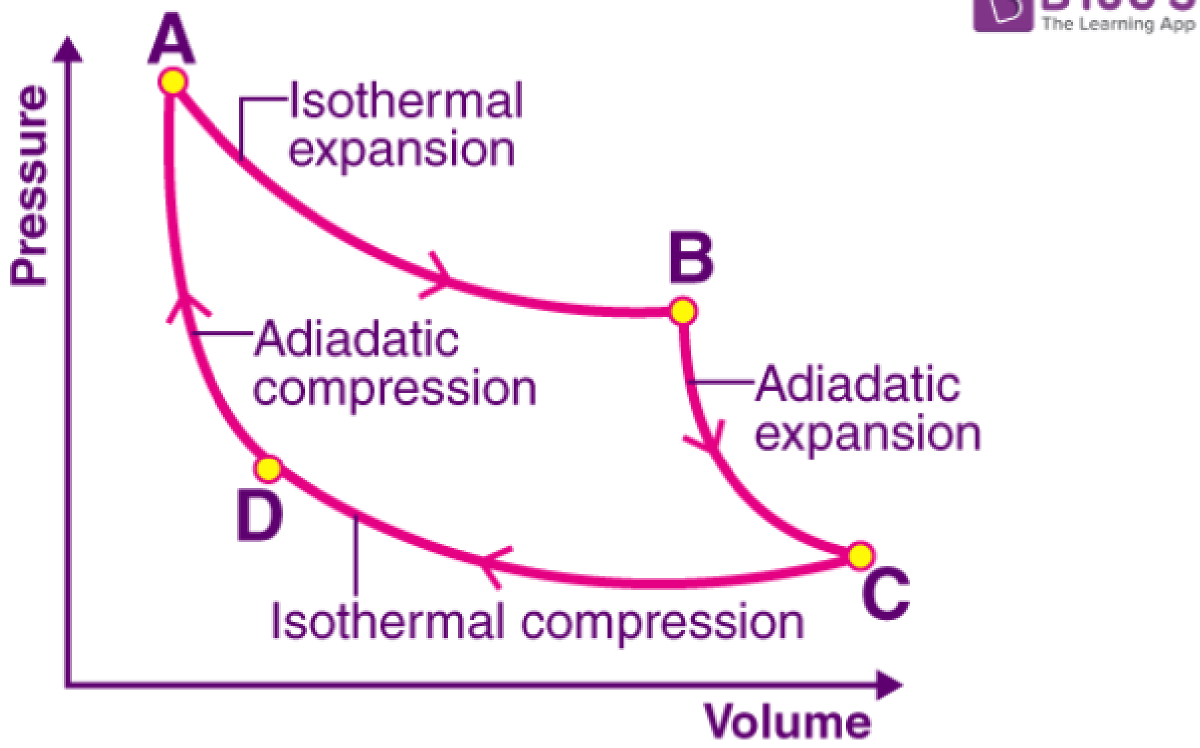
Answer: d) ΔU = 0
Explanation: When the temperature remains constant, isothermal expansion occurs. This suggests that ΔT = 0. Additionally, since internal energy depends on temperature, isothermal expansion results in zero internal energy.

Q-14: For the reaction X_2O_4 (l) → $2XO_2$ (g) at 298 K, given the values, ΔU = 9 kJ and ΔS = 84 JK^{-1}. Calculate ΔG.

Answer: Given reaction is X_2O_4 (l) → $2XO_2$ (g), T= 298 K
$\Delta U = 9$ kJ and $\Delta S = 84$ JK^{-1}, $\Delta H = ?$
$\Delta n_g = 2-0 = 2$

$\Delta H = \Delta U + \Delta n_g RT = 9kJ + 2\times8.314\times298 = (9000\ J + 4955.144)\ J = 13955.144\ J$
$\Delta G = \Delta H - T\Delta S = 13955.144\ J - (298\ K \times 84\ JK^{-1}) = -11076.856\ J = -11.08\ kJ$

Q-15: From the below Carnot cycle undergone by an ideal gas,identify the processes in which the change in internal energy is non-zero.



Answer: Internal energy (ΔU) is a function of temperature (ΔT) since, the temperature remains constant during an isothermal process, so change in internal energy is zero for isothermal process. For adiabatic processes (expansion as well as compression), q is zero but ΔT is not. So,ΔU is also non-zero.

Practise Questions on Internal Energy

Q-1: A system received a continuous supply of 600 joules of heat at constant volume.The system's temperature rose from 30 to 35 degrees Celsius as a result. In what ways has the system's internal energy changed?

Answer: At constant volume, $\Delta V= 0$.
Applying $\Delta E = q + w = q + P\Delta V$, we get $\Delta E = q = 600$ J

Q-2: Which energy is not the part of the internal energy?
a) Nuclear Energy
b) Chemical bond energy
c) Gravitational Energy
d) Potential Energy

Answer: c) Gravitational Energy
Explanation: Internal energy is the sum of all different types of energies associated with atoms and molecules such as electronic energy, nuclear energy, chemical bond energy, potential energy and kinetic energy. Gravitational energy is not the part of Internal energy.

Q-3: ΔU is zero in
a) Isobaric process
b) Cyclic process
c) Adiabatic process
d) Isochoric process

Answer: d) Cyclic process

Q-4: The molar enthalpy change for the condensation of 1 mol of water at 1 bar and 100 °C is 51kJ/mol if water vapour is taken to be a perfect gas. Determine the internal energy when 1 mol of water condenses at 100 °C and 1 bar of pressure.

Answer: The change $H_2O(g) \rightarrow H_2O(l)$
$\Delta H= \Delta U +\Delta n_g RT$
or $\Delta U= \Delta H - \Delta n_g RT$
$\Delta U= (51 \text{ kJ/mol}) - (-1)\times 8.314 \text{ JK}^{-1}\text{mol}^{-1} \times 373 \text{ K}$
$= 51 \text{ kJ/mol} + 3.10 \text{ kJ/mol}$
$= 53.10 \text{ kJ/mol}$

Q-5: Why is it preferable to determine the change in enthalpy than change in internal energy?

Answer: Change in enthalpy is the heat evolved or absorbed at constant pressure. As most of the reactions are carried out in open vessels i.e, at constant pressure of one atmosphere, hence change in enthalpy is preferred.