

**CHE-201**

**SUBJECTIVE MIDTERM- 100%**

**GUESS PAPER 2024**

**Physical Chemistry**

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## **SUBJECTIVES**

### **Importance of 3rd law of thermodynamics:**

1= It helps in calculating the thermodynamic properties. 2= It is helpful in measuring chemical affinity. Because of this it is known as Nernst theorem. 3= It explains the behavior of solids at very low temperature. 4= It helps in analyzing chemical and phase equilibrium.

### **Applications of Henry law**

Applicability of Henry's Law:

- ❖ Henry's law only works if the molecules are at equilibrium.
- ❖ Henry's law does not work for gases at high pressures (e.g.,  $N_2(g)$  at high pressure becomes very soluble and harmful when in the blood supply).
- ❖ Henry's law does not work if there is a chemical reaction between the solute and solvent (e.g.,  $HCl(g)$  reacts with water by a dissociation reaction to generate  $H_3O$  and  $Cl^-$  ions).

### **Write some factors that cause a process to become irreversible. / Why does a process become irreversible?**

1= Friction, 2= Unrestrained expansion and compression, 3= Mixing, 4= Heat transfer (finite  $\Delta T$ ), 5= Inelastic deformation, 6= Chemical reactions.

### **Describe Mass Percent, Volume Percent, Mass/Volume Percent:**

1. Mass Percent: The mass percent is used to express the concentration of a solution when the mass of a solute and the mass of a solution is given:

$$\text{Mass Percent} = \left( \frac{\text{Mass of Solute}}{\text{Mass of Solution}} \right) \times 100\%$$

2. Volume Percent: The volume percent is used to express the concentration of a solution when the volume of a solute and the volume of a solution is given:

$$\text{Volume Percent} = \left( \frac{\text{Volume of Solute}}{\text{Volume of Solution}} \right) \times 100\%$$

3. Mass/Volume Percent: Another version of a percentage concentration is mass/volume percent, which measures the mass or weight of solute in grams (e.g., in grams) vs. the volume of solution (e.g., in mL).

$$\text{Mass/Volume Percent} = \left( \frac{\text{Mass of Solute (g)}}{\text{Volume of Solution (mL)}} \right) \times 100\%$$

Example: For a solution with 10 grams of salt in 100 mL of water, the mass/volume percent is:

$$\text{Mass/Volume Percent} = \left( \frac{10\text{g}}{100\text{mL}} \right) \times 100\% = 10\%$$

### **Equilibrium thermodynamics:**

Equilibrium thermodynamics studies systems in a state of equilibrium, focusing on macroscopic properties without relying on molecular theories. It analyzes energy, work, and heat exchanges within a system at equilibrium, ensuring no net change occurs over time. This field contrasts with non-equilibrium thermodynamics, which deals with processes and systems not in equilibrium.

### **Three types of Equilibrium thermodynamics:**

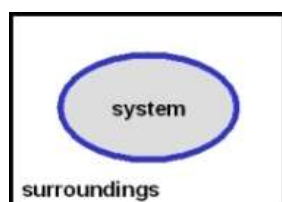
**Mechanical Equilibrium:** No unbalanced forces act on or within the system; hence the system undergoes no acceleration, and there is no turbulence within the system.

**Material Equilibrium:** No net chemical reactions are occurring in the system, nor is there any net transfer of matter from one part of the system to another or between the system and its surroundings.

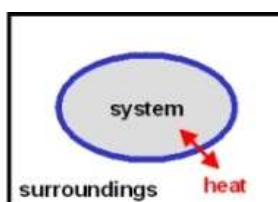
**Thermal Equilibrium** between a system and its surroundings, there must be no change in the properties of the system or surroundings when they are separated by a thermally conducting wall. For thermodynamic equilibrium, all three kinds of equilibrium must be present.

### **Differentiate between open, closed and isolated system?**

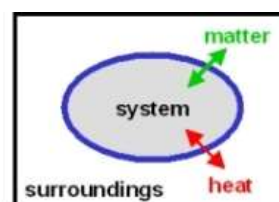
The macroscopic part of the universe under study in thermodynamics is called the System. The parts of the universe that can interact with the system are called the surroundings. 1= Open system is one where transfer of matter between system and surroundings can occur. 2= Closed system is one where no transfer of matter can occur between system and surroundings. 3= Isolated system is one that does not interact in any way with its surroundings. An isolated system is obviously a closed system, but not every closed system is isolated.



"Isolated" system:  
• no exchange of matter  
• no exchange of heat



"Closed" system:  
• no exchange of matter  
• can exchange heat energy



"Open" system:  
• can exchange matter  
• can exchange heat energy

### **Carbon dioxide is polar or non-polar Explain:**

CO<sub>2</sub> is non-polar. Despite having polar C=O bonds with the central carbon positively charged and outer oxygens negatively charged, the molecule's linear structure causes the bond dipoles to cancel each other out, resulting in a net zero dipole moment (p=0). Thus, the overall molecule has no polarity.

### **Ideal gas equation and how it can be corrected:**

The ideal gas equation is  $PV = nRT$ , where  $P$  is pressure,  $V$  is volume,  $n$  is the number of moles,  $R$  is the gas constant, and  $T$  is temperature. It assumes no intermolecular forces and that gas molecules occupy no volume. Real gases deviate from this behavior at high pressures and low temperatures. Corrections are made using the Van der Waals equation:  $(P + \frac{a}{V^2})(V - b) = nRT$ , where  $a$  and  $b$  account for intermolecular forces and molecular volume, respectively.

### **Describe Le Chatelier's Principle and reaction to temperature, pressure:**

#### **Le Chatelier's Principle**

Le Chatelier's Principle states that if a dynamic equilibrium is disturbed by changing the conditions, the position of equilibrium will move to counteract the change. This applies to changes in concentration, pressure, and temperature.

#### **Reaction to Temperature**

If the temperature increases, the equilibrium shifts to favor the endothermic reaction, absorbing excess heat. If the temperature decreases, the equilibrium shifts to favor the exothermic reaction, releasing heat.

#### **Reaction to Pressure**

For gas reactions, increasing pressure shifts equilibrium toward the side with fewer gas molecules, reducing pressure. Decreasing pressure shifts it toward the side with more gas molecules, increasing pressure.

### **Write the application of equilibrium constant:**

#### **1. Extent of Reaction:**

- A large  $K$  means high product concentration; reaction proceeds to the right.
- A small  $K$  means high reactant concentration; reaction proceeds to the left.

#### **2. Direction Prediction:**

- If  $Q=K_c$ , system is at equilibrium.
- If  $Q>K_c$ , reaction proceeds left.
- If  $Q<K_c$ , reaction proceeds right.

#### **3. Equilibrium Concentration Calculation:**

- Determines the concentration of reactants or products at equilibrium.

### **Define the following terms. 1= critical volume, 2= critical pressure, 3= critical temperature:**

The Critical Volume: The volume occupied by a unit mass of a gas or vapors in its critical states.

The Critical Pressure: The pressure required to liquefy a gas at its critical temperature.

The Critical Temperature: The temperature at and above which vapors of the substance cannot be liquefied, no matter how much pressure is applied.

### **Why ions occur in polar and non-polar with dipole moment**

#### **Reason for Ion Occurrence in Polar and Non-Polar Molecules with Dipole Moments**

**Polarity and Dipole Moments:** Ions occur in polar molecules due to unequal electron sharing, creating a dipole moment ( $\mu=Q \times r$ ). Non-polar molecules, being symmetric, have dipole moments that cancel out, resulting in no net dipole. Thus, polar molecules have net dipole moments, while non-polar ones do not.

### **How viscosity is measured by Ostwald's viscometer?**

Ostwald Viscometer:

An Ostwald Viscometer consists of two reservoir bulbs and a capillary tube. •The viscometer is filled with liquid until the liquid reaches the mark A with the aid of a pipette to accurately measure out the volume of needed liquid. • The viscometer is then put into a water bath which equilibrates the temperature of the test liquid. • As noted before, the equilibration is important to maintain a constant temperature as to not affect the viscosity otherwise. • The liquid is then drawn through the side 2 of the U-tube by use of suction and lastly, the flow is time between marks C and B. • The viscosity is calculated with Equation  $\nu = Kt$  Where K is the value of a liquid with known viscosity and density such as water. Once the value of K is known, the viscosity can be determined by measuring the amount of time the test liquid flows between the two graduated marks.

### **Briefly explain the third law of thermodynamics?**

Entropy of a perfect crystalline substance is zero at absolute zero.

Importance of this law: it allows us to calculate absolute entropies for substances.

“It is impossible to reach a temperature of absolute zero.”

On the Kelvin Temperature Scale,

$T=0K$

is often referred to as

"Absolute Zero"

The Third Law of Thermodynamics can mathematically be expressed as

$$\lim_{T \rightarrow 0} S_T = 0$$

Where

S = entropy (J/K)

• T = absolute temperature

(K)

### **Describe the types of specific latent heat?**

There are two types of specific latent heat: • vaporization and fusion.

The specific latent heat of vaporization: The specific latent heat of vaporization is defined as the quantity of heat energy that is necessary to raise one unit of weight (pounds or grams) with no change of temperature in the surroundings. Like the name implies, this specific latent heat quantifies the transfer of energy when a substance's state changes from liquid to gas or from gas to liquid.

Specific Latent heat of fusion: The specific heat of fusion is the quantity of heat that is necessary to raise one unit of weight without any change in temperature. This specific latent heat quantifies the transfer of energy when a substance's state changes from a solid to a liquid or from a liquid to a solid.

### **Describe some reversible reaction which are in surrounding?**

Reversible Process: A reversible process is defined as a process that can be reversed without leaving any trace on the surroundings. Examples: 1= Frictionless relative motion. 2= Expansion and compression of spring. 3= Isothermal expansion or compression. 4= Electrolysis.

### **How ionic solution formed explain / What is energy process involved in ionic compound formation?**

Formation of Ionic Solutions

**1. Assessment of Forces:** Ionic solutions form when the ion-dipole forces between water and the ionic compound surpass the interionic bonds. This requires stronger attraction between water and ions compared to the bonds within the ionic compound.

**2. Process:**

- ❖ **Breaking Ionic Bonds:** Endothermic process requiring energy.
- ❖ **Hydrating Cations:** Exothermic, releases energy.
- ❖ **Hydrating Anions:** Exothermic, also releases energy.

**3. Enthalpy of Solution:** The sum of these steps determines the enthalpy of the solution, crucial for understanding energy changes in the formation of ionic solutions.

### **Why ice floats on water?**

Ice floats on water because it is less dense than liquid water. At 4°C, water reaches its maximum density, but upon freezing, molecules arrange into an open hexagonal structure, increasing volume by about 9%, making ice less dense. This unique property allows ice to float on water.

### **Extensive and intensive thermodynamics:**

An extensive thermodynamic property is one whose value is equal to the sum of its values for the parts of the system. Thus, if we divide a system into parts, the mass of the system is the sum of the masses of the parts; mass is an extensive property. So is volume.

Intensive thermodynamic property is one whose value does not depend on the size of the system, provided the system remains of macroscopic size—recall nanoscopic systems. Density and pressure are examples of intensive properties.

### **Effect of temperature in heat capacity:**

Specific heat or Heat Capacity is a measure of the ability of the substance to absorb heat. The heat goes first into increasing the kinetic energies of the molecules.

- ❖ Molecules can also store energy in vibrations and rotations.
- ❖ At low temperatures, collisions do not provide enough energy to get out of the ground states for rotation or vibration.
- ❖ As the substance heats up, the average kinetic energy of the molecules increases. The collisions impart enough energy to allow rotation to occur.
- ❖ Rotation then contributes to the internal energy and raises the specific heat.

### **Energy used in ionic solution formation:**

Energy is required to overcome the attractive forces between ions in their solid state and to separate them into individual ions in solution, known as lattice energy. Additionally, energy may be released or absorbed during hydration of ions, contributing to overall energy changes in ionic solution formation.

### **Henry's law**

State Henry's law. Henry's law is one of the gas laws formulated by William Henry in 1803 and states:

"At a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid."

### **Physical properties of liquid**

1= The physical properties of a substance depend upon its physical state. 2= Water vapor, liquid water and ice all have the same chemical properties, but their physical properties are considerably different. 3= Intermolecular forces (non-covalent bonds) influence the physical properties of liquids. 4= The molecules in liquids are very close together, with essentially no

empty space between them. 5= As in gases, however, the molecules in liquids are in constant motion, and their kinetic energy (and hence their speed) depends on their temperature.

### **Two statements of the second law of thermodynamics**

1= Clausius Statement: It is impossible to construct a device that operates in a cycle and whose sole effect is to transfer heat from a cooler body to a hotter body.

2= Kelvin-Planck Statement: It is impossible to construct a device that operates in a cycle and produces no other effects than the performance of work and the exchange of heat with a single reservoir.

### **Reasons of failure of ideal gas equation**

The ideal gas equation fails to fully describe real gases under conditions of high pressure or low temperature. At high pressures, gas molecules are closer together, increasing intermolecular forces and reducing molecular volume, which the ideal gas equation doesn't account for. At low temperatures, gas molecules move slower, causing intermolecular attractions to become significant, leading to deviations from ideal behavior. These conditions necessitate corrections like the Van der Waals equation to accurately predict gas behavior.

### **Explain laws of thermodynamics:**

The laws of thermodynamics govern energy and its transformations. The first law states that energy is conserved, neither created nor destroyed, only transformed. The second law introduces entropy, indicating that in isolated systems, entropy tends to increase, reflecting the natural tendency towards disorder. The third law sets a limit to reaching absolute zero, stating it is impossible to reach this temperature through any finite number of steps. These laws form the foundation of understanding energy transfer and system behavior.

### **ONLY FOR YOUR KIND INFORMATION:**

1st Law of Thermodynamics - Energy cannot be created or destroyed.

2nd Law of Thermodynamics - For a spontaneous process, the entropy of the universe increases.

3rd Law of Thermodynamics - A perfect crystal at zero Kelvin has zero entropy.

### **How solid state float on liquid state:**

Solid-state objects float on liquid-state ones when their density is lower than that of the liquid. Archimedes' principle explains this: the buoyant force acting upward on the solid equals the weight of the liquid displaced, allowing the solid to float.