MHT CET 2023 Question Paper with Answers and Solution May 9 Shift 1 (Memory-based)

Ques 1. identify the element with the electronic configuration $1s^2 1p^4$?

Ans: Sulphur

Solution: The element with the electronic configuration **$1s^2 1p^4$**is sulfur (S), which has 16 electrons.

The electronic configuration of sulfur can be written as:
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

In this configuration, the first two electrons occupy the 1s orbital, the next two electrons occupy the 2s orbital, and the next six electrons occupy the

2p orbital. The remaining four electrons are distributed between the 3s and 3p orbitals, with the last four electrons occupying the 3p orbital.

Ques 2. What is the correct expression for enthalpy?

Ans. H = U + PV

Solution: Enthalpy is a thermodynamic property of a system that represents the total heat content of the system at constant pressure. It is denoted by the symbol H and is defined as:

H = U + PV

where:

- U is the internal energy of the system
- P is the pressure of the system
- V is the volume of the system

The expression H = U + PV is known as the enthalpy equation, and it shows that the enthalpy of a system is the sum of its internal energy and the product of its pressure and volume. The enthalpy of a system is often expressed in units of joules (J) or kilojoules (kJ).

Ques 3. A circuit is given with R=200 ohm,Voltage = 3V, what will be the current?

Ans. 0.015 A or 15 mA

Solution: To calculate the current in a circuit, you can use Ohm's law, which states that the current flowing through a conductor between two points is directly proportional to the voltage and inversely proportional to the resistance. The formula for Ohm's law is:

I = V/R

Where I is the current in amperes (A), V is the voltage in volts (V), and R is the resistance in ohms (Ω).

Using the given values of R=200 ohm and V=3V, we can calculate the current as:

I = 3V / 200 ohm = 0.015 A or 15 mA (milliamperes)
Therefore, the current in the circuit is 0.015 A or 15 mA.

Ques 4. The total energy of simple harmonic oscillations is directly proportional to?

Ans. Total energy is directly proportional to square of amplitude. **Solution:** The total energy of a simple harmonic oscillator is directly proportional to the square of its amplitude.

A simple harmonic oscillator is a system that exhibits periodic motion around a fixed equilibrium point, where the motion is sinusoidal and can be described by the equation:

$x(t) = A \sin(\omega t + \varphi)$

where x is the displacement of the oscillator from its equilibrium position, A is the amplitude of the motion, ω is the angular frequency of the oscillation, t is time, and φ is the phase angle.

The total energy of the oscillator is the sum of its kinetic energy and potential energy, and it is given by the equation:

$E = (1/2)\, k\, A^2$

where k is the spring constant of the oscillator. As we can see from this equation, the total energy of the oscillator is directly proportional to the square of its amplitude. This means that as the amplitude of the oscillator increases, so does its total energy.

Ques 5. Which metal catalyst is used to prepare sulphuric acid in contact process?

Ans. Vanadium pentoxide

Solution: The contact process is a widely used method for producing sulfuric acid industrially. This process involves the use of a catalyst to help promote the oxidation of sulfur dioxide to sulfur trioxide. The most commonly used catalyst in the contact process is vanadium pentoxide (V_2O_5).

Vanadium pentoxide is used as a solid catalyst, which is packed into a reactor where it is exposed to a mixture of sulfur dioxide, oxygen, and nitrogen gases. The reaction between sulfur dioxide and oxygen is highly exothermic and produces sulfur trioxide gas.

The overall reaction can be represented by the following equation: $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

The sulfur trioxide is then absorbed into a solution of sulfuric acid, where it reacts to form more sulfuric acid. This step is highly exothermic and releases a significant amount of heat.

The contact process using vanadium pentoxide as a catalyst is highly efficient and allows for the production of high-quality sulfuric acid on an industrial scale.

Ques 6. Find ratio of angular speeds of second hand and minute hand?

Ans. 60:1

Solution: The second hand of a clock completes one full rotation in 60 seconds, while the minute hand completes one full rotation in 60 minutes, or 3600 seconds. Therefore, the ratio of the angular speeds of the second hand and minute hand is:

Angular speed of second hand / Angular speed of minute hand = (2π radians / 60 seconds) / (2π radians / 3600 seconds)

Simplifying this expression:

Angular speed of second hand / Angular speed of minute hand = $(2\pi / 60) / (2\pi / 3600) = (2\pi / 60) \times (3600 / 2\pi) = 3600 / 60 = 60/1$

Therefore, the ratio of the angular speeds of the second hand and minute hand is 60:1. This means that the second hand rotates 60 times faster than the minute hand.

Ques 7. If at depth ‘d’ the gravitational force acting on a particle is 300

N, then what is the force on a particle at depth ‘d/2’?

Ans. 150 N

Ques 8. If there is a charge on the surface of sphere, what will be the electric field inside the sphere?

Ans. 0
Solution: If there is a charge on the surface of a conducting sphere, the electric field inside the sphere will be zero.

This is due to the fact that a conducting sphere is a material with high conductivity, and any charge placed on its surface will distribute itself uniformly over the surface. The electric field inside a conductor is always zero, regardless of the shape of the conductor, since any electric field inside the conductor would result in a flow of charges, which would redistribute the charges until the electric field is canceled out.

Thus, if there is a charge on the surface of a conducting sphere, the electric field inside the sphere will be zero, since any electric field inside the sphere would cause charges to move until the electric field is zero. This is true even if the sphere is not a perfect conductor but has some resistance, as long as the conductivity is high enough to allow for the uniform distribution of the charge.

Ques 9. What is the correct condition for an LCR circuit to be at resonance?
Solution: An LCR (inductor-capacitor-resistor) circuit is said to be at resonance when the inductive reactance and capacitive reactance in the circuit cancel out each other, leaving only the resistance in the circuit. This results in maximum current flow through the circuit and maximum energy transfer between the inductor and the capacitor.

The condition for an LCR circuit to be at resonance is given by the resonance frequency formula:

$f = 1 / (2\pi\sqrt{LC})$

where:

- f is the frequency of the AC source
- L is the inductance of the inductor in the circuit, measured in henries (H)
- C is the capacitance of the capacitor in the circuit, measured in farads (F)
- π is the mathematical constant pi (approximately equal to 3.14) At resonance, the inductive reactance (XL) and capacitive reactance (XC) in the circuit are equal in magnitude but opposite in sign, i.e., XL = -XC. The impedance of the circuit (Z) is given by:

$Z = \sqrt{(R^2 + (XL - XC)^2)}$

where:

- R is the resistance in the circuit, measured in ohms (Ω)

At resonance, XL = -XC, so the term (XL - XC) in the above equation becomes zero, and the impedance of the circuit is equal to the resistance

R. This means that the circuit behaves like a pure resistive circuit, with maximum current flow through it and maximum power transfer between the inductor and the capacitor.

Therefore, the condition for an LCR circuit to be at resonance is when the frequency of the AC source is equal to the resonance frequency given by the formula $f = 1 / (2\pi\sqrt{LC})$, and the inductive reactance and capacitive reactance in the circuit are equal in magnitude but opposite in sign.

Ques 10. Find the packing efficiency of silver metal? Ans: 74%

Solution: The packing efficiency of a metallic crystal is a measure of how efficiently the constituent atoms are packed together in the crystal lattice. It is defined as the ratio of the volume occupied by the atoms in the unit cell to the total volume of the unit cell.

For face-centered cubic (FCC) metals such as silver (Ag), the packing efficiency is given by:

packing efficiency = (number of atoms per unit cell) x (volume of one atom)

/ (volume of the unit cell)

In an FCC lattice, each corner atom is shared between eight unit cells, while each face-centered atom is shared between two unit cells. Therefore, the number of atoms per unit cell in an FCC lattice is 4.

The volume of one atom of silver can be calculated using the atomic radius, which is known to be 144 picometers (pm) for silver. The volume of one atom can be calculated using the formula for the volume of a sphere: volume of one atom = $(4/3) \times \pi \times (\text{atomic radius})^3$

Substituting the value of the atomic radius of silver, we get:

volume of one atom = $(4/3) \times \pi \times (144 \text{ pm})^3 = 2.52 \times 10^{-23} \text{ cm}^3$

The volume of the unit cell in an FCC lattice can be calculated using the formula:

volume of the unit cell = $(a^3) / 4$,

where 'a' is the length of one side of the unit cell.

The length of one side of the unit cell can be calculated using the relationship between the atomic radius and the length of the diagonal of the unit cell:

$a = (2 \times \text{atomic radius}) / \sqrt{2}$

Substituting the value of the atomic radius of silver, we get: $a = (2 \times 144 \text{ pm}) / \sqrt{2} = 408.3 \text{ pm}$
Converting this value to centimeters, we get:

$a = 4.083 \times 10^{-8}$ cm

Substituting this value in the formula for the volume of the unit cell, we get: volume of the unit cell = $(4.083 \times 10^{-8} \text{ cm})^3 / 4 = 6.21 \times 10^{-24} \text{ cm}^3$ Now, substituting the values for the number of atoms per unit cell, the volume of one atom, and the volume of the unit cell, we get:

packing efficiency = $(4 \times 2.52 \times 10^{-23} \text{ cm}^3) / (6.21 \times 10^{-24} \text{ cm}^3) = 0.74$ Therefore, the packing efficiency of silver metal is approximately 0.74 or 74%.

Ques 11. Find the differentiation of $\cot^{-1}((3+4\tan x)/(4-3\tan x))$. Ans. $48\sec^2 x / [(3\tan x - 4)^2 + 25]$

Solution: To find the derivative of $\cot^{-1}((3+4\tan x)/(4-3\tan x))$, we can use the chain rule and the derivative of the inverse cotangent function. Let $u = (3 + 4\tan x)/(4 - 3\tan x)$

Then, $\cot^{-1}((3+4\tan x)/(4-3\tan x)) = \cot^{-1}(u)$
Differentiating both sides with respect to x, we get:
$d/dx [\cot^{-1}(u)] = d/dx [\cot^{-1}((3+4\tan x)/(4-3\tan x))]$ Using the chain rule, we have:
$d/dx [\cot^{-1}(u)] = -1/[1 + u^2] * du/dx$

To find du/dx, we can use the quotient rule:

$du/dx = [(4 - 3\tan x)(4\sec^2 x) - (3 + 4\tan x)(3\sec^2 x)] / (4 - 3\tan x)^2$
Simplifying this expression, we get:

$du/dx = -48\sec^2 x / (4 - 3\tan x)^2$

Substituting this expression for du/dx into our earlier equation, we get: $d/dx\ [\cot^{-1}((3+4\tan x)/(4-3\tan x))] = -1/[1 + u^2] * [-48\sec^2 x / (4 - 3\tan x)^2]$
Simplifying this expression, we get:
$d/dx\ [\cot^{-1}((3+4\tan x)/(4-3\tan x))] = 48\sec^2 x / [(3\tan x - 4)^2 + 25]$

Therefore, the derivative of $\cot^{-1}((3+4\tan x)/(4-3\tan x))$ is $48\sec^2 x / [(3\tan x - 4)^2 + 25]$.

Ques 12. Find the change in the charge carriers of a p-n junction diode if its temperature is increased?

Ques 13. Find the height of a conical pendulum if the time period is given?

Ques 14. What is the value of the specific rotation of the glucose molecule?