MHT CET 2023 Question Paper with Answers and Solution May 10 Shift 2 (Memory-based)

Question 1. For a BCC structure, if a = 351 pm, find r. Lithium forms a BCC structure having an edge length of a unit cell 351 pm, then find the atomic radius of lithium.

Answer. 1.53 Å.

Solution. For a BCC (body-centered cubic) structure, the relationship between the lattice constant (a) and the atomic radius (r) is:

$a = 4\sqrt{(2)}r/3$

Solving for r, we get: $r = (3a/4\sqrt{(2)})$

Substituting the given value of a = 351 pm (or 3.51 Å), we get:

$r = (3 \times 3.51 \text{ Å}) / (4\sqrt{(2)})$ $r \approx 1.53$ Å

Therefore, the atomic radius of lithium in its BCC structure is approximately 1.53 Å.

Question 2. Identify allylic halide and vinylic halide.

Answer. An allylic halide is a halogenated organic compound where the halogen atom is bonded to an allylic carbon, which is a carbon atom that is adjacent to a carbon-carbon double bond. For example, 3-chloropropene is an allylic halide because the chlorine atom is bonded to the allylic carbon:

$CH2=CH-CH2Cl$

A vinylic halide is a halogenated organic compound where the halogen atom is bonded to a vinyl carbon, which is a carbon atom that is part of a carbon-carbon double bond. For example, chloroethene is a vinylic halide because the chlorine atom is bonded to the vinyl carbon:

$CH_2{=}CHCl$

Question 3. Find the surface tension at critical velocity? Answer. 1.25 N/m.

Solution. The surface tension at critical velocity can be determined using the following formula:

$\gamma = (\rho v^2) / (2r)$ where:
γ is the surface tension of the liquid ρ is the density of the liquid
v is the critical velocity of the liquid
r is the radius of the tube or capillary
The critical velocity is the velocity at which a liquid flowing through a tube or capillary changes from laminar flow to turbulent flow. At this velocity, the surface tension of the liquid is balanced by the inertial forces of the flowing liquid.

Let's assume that we have a tube of radius $r = 0.1$ cm, and we want to find the surface tension of a liquid with density $\rho = 1000$ kg/m^3 at the critical velocity $v = 50$ cm/s.

First, we need to convert the units of density and velocity to be consistent with each other. We can convert the density to kg/cm^3 by dividing it by 1000, and the velocity to m/s by dividing it by 100:

$\rho = 1000$ kg/m^3 = 1 kg/cm^3 $v = 50$ cm/s = 0.5 m/s

Now we can plug these values into the formula:

$\gamma = (\rho v^2) / (2r)$
$\gamma = (1 \times 0.5^2) / (2 \times 0.1)$

$\gamma = 1.25$ N/m

Therefore, the surface tension at critical velocity is 1.25 N/m.

Question 4. In a certain culture of bacteria the rate of increase is proportional to the no.of bacteria present at that instant it is found that there are 10000 bacteria present in 3 hours and 40000 bacteria at the 5 hours the number of bacteria present in the beginning is?

Answer. 2593

Solution. We can use the general formula for exponential growth to solve this problem, which is:

N(t) = N0 * e^(kt) where:
N(t) is the number of bacteria at time t

N0 is the initial number of bacteria
k is the constant of proportionality (the growth rate)
e is the base of the natural logarithm, approximately equal to 2.71828... To find the value of N0, we need to use the information given in the problem. We are told that the rate of increase is proportional to the number of bacteria present, which means that:

dN/dt = kN

where dN/dt is the rate of change of the number of bacteria with respect to time.

We can solve this differential equation by separating the variables and integrating both sides:

(dN/N) = k*dt ln(N) = kt + C N = e^(kt+C) N = Ce^(kt)

Here, C is the constant of integration, which we can determine using the initial condition that there are 10000 bacteria present in 3 hours. Plugging in these values, we get:

10000 = Ce^(3k)

Similarly, we can use the condition that there are 40000 bacteria present at 5 hours:

40000 = Ce^(5k)

Now we can solve these two equations simultaneously to find the values of C and k:

10000 = Ce^(3k)

40000 = Ce^(5k)

Dividing the second equation by the first equation, we get: 4 = e^(2k)
Taking the natural logarithm of both sides, we get:

ln(4) = 2k

Solving for k, we get:

k = ln(4) / 2 = 0.6931

Substituting this value of k into either of the two equations, we can solve for C:

10000 = Ce^(3k)
10000 = Ce^(2.079)

$C = 10000 / e^{(2.079)} = 2593.39$ (rounded to two decimal places)
Therefore, the initial number of bacteria is:
$N_0 = Ce^{(kt)} = 2593.39 * e^{(0.6931*0)} = 2593.39$

So there were approximately 2593 bacteria present in the beginning.

Question 5. Edge length of a unit cell of a crystal is 288 pm. If its density is 7.2 g/cm3, then determine the type of unit cell assuming mass = 52 g.

Answer. The FCC unit cell has 4 formula units per unit cell

Solution. We can use the formula for the density of a crystal in terms of its unit cell parameters:

$$\rho = (ZM) / (VN\_A^*)$$

where:

ρ is the density of the crystal
Z is the number of atoms per unit cell M is the molar mass of the substance
V is the volume of the unit cell
N_A is Avogadro's constant
To determine the type of unit cell, we need to first calculate the volume of the unit cell using the edge length. For a cubic unit cell, the volume is given by:

$$V = a^3$$

where a is the edge length. Substituting the given values, we get:
$V = (288 \text{ pm})^3 = (288 \times 10^{-10} \text{ m})^3 = 2.359 \times 10^{-23} \text{ m}^3$
Now we can use the given density and mass to solve for Z: $\rho = (ZM) / (VN_A)$
$7.2 \text{ g/cm}^3 = (Z52 \text{ g/mol}) / (2.359 \times 10^{-23} \text{ m}^3 * 6.022 \times 10^{23}\text{/mol})$ Z =

(7.2 g/cm^3 * 2.359 x 10^-23 m^3 * 6.022 x 10^23/mol) / (52 g/mol) Z ≈ 4

The value of Z suggests that the crystal has a face-centered cubic (FCC) unit cell. The FCC unit cell contains 4 atoms, with atoms located at the corners and in the center of each face of the cube. Therefore, we can conclude that the crystal has an FCC structure.

Question 6. What type of bonds are present in molecular crystals?
Answer. Covalent Bond
Solution.
Molecular crystals are made up of individual molecules held together by intermolecular forces. The bonding between the atoms within each molecule is typically covalent in nature, where electrons are shared between adjacent atoms to form molecular bonds. The intermolecular forces that hold the molecules together in a crystal lattice are weaker than covalent bonds and include London dispersion forces, dipole-dipole forces, and hydrogen bonding. These intermolecular forces arise from the interactions between the partially charged atoms or molecules in the crystal lattice. So, in a molecular crystal, covalent bonds are present within the molecules, while intermolecular forces are present between the molecules.

Question 7. The radius of a cylinder is increasing at the rate 2 cm/sec and its height is decreasing at the rate 3 cm/sec, then find the rate of change of volume when the radius is 3cm and the height is 5 cm.

Answer. 3π cubic cm/sec

Solution. The volume of a cylinder is given by the formula V = πr^2h, where r is the radius and h is the height.

We are given that the radius is increasing at the rate of 2 cm/sec, which means dr/dt = 2 cm/sec, and that the height is decreasing at the rate of 3 cm/sec, which means dh/dt = -3 cm/sec.

We want to find the rate of change of volume when the radius is 3 cm and the height is 5 cm. So, we need to find dV/dt when r = 3 cm and h = 5 cm.

Using the product rule of differentiation, we can write: $dV/dt = \pi(2rh)(dr/dt) + \pi(r^2)(dh/dt)$

Substituting the given values, we get: $dV/dt = \pi(2 \times 3 \times 5)(2) + \pi(3^2)(-3)$

$dV/dt = 30\pi - 27\pi$

$dV/dt = 3\pi$

Therefore, the rate of change of volume when the radius is 3cm and the height is 5 cm is 3π cubic cm/sec.

Question 8. What is the unit of Henry's law constant?

Answer. $m^3 \cdot Pa/mol$

Solution. The unit of Henry's law constant (kH) depends on the units of the partial pressure of the gas and the concentration of the gas in the liquid phase.

If the partial pressure of the gas is in atmospheres (atm) and the concentration of the gas in the liquid phase is in moles per liter (M), then the units of kH are:

L•atm/mol

If the partial pressure of the gas is in pascals (Pa) and the concentration of the gas in the liquid phase is in moles per cubic meter (mol/m^3), then the units of kH are:

$m^3 \cdot Pa/mol$

Question 9. The area spherical balloon of radius 6 cm increases at the rate of 2 then find the rate of increase in the volume.

Answer. 0 cubic cm/sec.

Solution. We can use the formulas for the surface area and volume of a sphere to solve this problem. The surface area of a sphere with radius r is given by:

$A = 4\pi r^2$

And the volume of a sphere with radius r is given by: $V = (4/3)\pi r^3$ We are given that the surface area is increasing at the rate of 2 cm^2/sec. That is, $dA/dt = 2$ cm^2/sec. We want to find the rate of change of the volume when the radius is 6 cm.

Using the formulas for A and V, we can find the relationship between the rate of change of surface area and the rate of change of volume:

$dA/dt = 8\pi r(dr/dt)$ $dV/dt = 4\pi r^2(dr/dt)$
Here, dr/dt is the rate of change of the radius, which we don't know. However, we know that the radius is constant with respect to time, so $dr/dt = 0$. Therefore, we have:

$dV/dt = 4\pi r^2(dr/dt) = 4\pi r^2(0) = 0$

This means that the volume is not changing with respect to time when the radius is constant.

However, we are given that the radius is increasing at the rate of 2 cm/sec. That is, $dr/dt = 2$ cm/sec. So, the rate of change of the radius is positive. Therefore, the volume is increasing, but the rate of increase is zero when the radius is constant.

In summary, when the radius of the spherical balloon is 6 cm and is increasing at the rate of 2 cm/sec, the rate of increase in the volume is 0 cubic cm/sec.

Question 10. ∫ex (1 - cotx + cot2x) dx = ?

Question 11. Find the differential equation of all circles passing through the origin and having their centres on the x-axis.

Question 12. The sum of mean and variance of a given set is 15/2 and their number of trials is 10, then find the value of variance?

Question 13. If f(x) = derivative of a sin3x wrt acos3x, then find f''(x).

Question 14. If x = 3tant and y = 3 sect, then find d2y/dx2? Question 13. ∫01cos-1x dx = ?

Question 15. ∫ (x2 - 1)dx/(x3(2x4 - 2x2 1)1/2) = ? Question 15. ∫0π (xtanx) dx/(secx + cosx) = ?