## MCQ 50 marks

1. **B. Solubility in pure water is about** 7450 **times higher than in** $NaCl$ **solution**

**Explanation:** In pure water, $S_{water} = \sqrt{K_{sp}} \approx 1.34 \times 10^{-5}$ M.

In 0.1 M $NaCl$, due to the common ion effect, $S_{NaCl} = \frac{K_{sp}}{0.1} = 1.8 \times 10^{-9}$ M.

The ratio is ≈ 7450 times, showing the common ion effect sharply reduces solubility.

2. **B. Yes, precipitation will occur**

**Explanation:** After mixing, $[Ba^{2+}] = 0.01$ M, $[SO_4^{2-}] = 0.025$ M.

$K_{ip} = 0.01 \times 0.025 = 2.5 \times 10^{-4} \gg K_{sp}(1.1 \times 10^{-10})$, so precipitation will occur.

3. **A. Nernst distribution law**

**Explanation:** Solvent extraction is based on the Nernst Distribution Law, which states that the distribution ratio of a solute between two immiscible solvents is constant at a given temperature.

4. **C.** 200 g

**Explanation:** A solubility of 50 means 150 g of solution (100 solvent +50 solute) contains 50 g of salt.

In 600 g of solution, salt = $\frac{50 \times 600}{150} = 200$ g.

5. **B.** 0 **to** 1 **(inclusive)**

**Explanation:** $R_f = \frac{\text{distance travelled by solute}}{\text{distance travelled by solvent front}}$. Since the solute cannot travel farther than the solvent front, $R_f$ always lies between 0 and 1 (inclusive).

6. **D.** $K^+$**: light violet turning to pink;** $Na^+$**: golden yellow turning to invisible**

**Explanation:** $K^+$ gives a light violet flame to the naked eye, which appears more distinctly pink/violet through cobalt blue glass (the glass absorbs yellow light, removing sodium interference).

$Na^+$ gives a bright golden yellow flame to the naked eye, but cobalt blue glass fully absorbs that yellow light, making it invisible.

7. **B. Metal chlorides are more volatile, so they vaporize easily in the flame**

**Explanation:** Metal chloride compounds are generally more volatile than other salts (such as sulfates or carbonates), so they vaporize easily in the flame to display the metal's characteristic colour; hence concentrated $HCl$ is used to make the paste.

8. **C.** $SO_4^{2-} + BaCl_2 \rightarrow BaSO_4 \downarrow$ **(white, insoluble in** $HCl$**)**

**Explanation:** Adding $BaCl_2$ solution to identify $SO_4^{2-}$ gives a white $BaSO_4$ precipitate that remains insoluble even in dilute $HCl$ — this is the confirmatory test for $SO_4^{2-}$. The first option is a test for $Cl^-$, which is not the correct answer here.

9. **A. Stationary phase: silica gel/alumina; mobile phase: petroleum ether/hexane**

**Explanation:** In ordinary column chromatography, polar silica gel/alumina is used as the stationary phase and a non-polar solvent (petroleum ether, hexane) as the mobile phase, which is effective for separating non-polar compounds.

10. **B. A white precipitate forms which dissolves in excess** $NaOH$

**Explanation:** $Zn^{2+} + 2OH^- \rightarrow Zn(OH)_2 \downarrow$ (white); on adding excess $NaOH$, $Zn(OH)_2 + 2OH^- \rightarrow [Zn(OH)_4]^{2-}$(soluble zincate).

**A. The $3d^{10}4s^1$ configuration gains extra exchange energy from the symmetry of a**

11. **fully filled d-subshell**

**Explanation:** A fully filled ($d^{10}$) or half-filled ($d^5$) d-subshell gains maximum exchange energy from the symmetric electron distribution, giving extra stability — so one 4s electron shifts into the 3d subshell.

12. **A. For the solubility of a gaseous solute**

**Explanation:** According to Henry's law, at a given temperature, the solubility of a gas dissolved in a liquid is proportional to the partial pressure of the gas ($S \propto P$). Pressure has no significant effect on the solubility of solid or liquid solutes.

13. **D. All of the above**

**Explanation:** $Na^+(10e^-)$, $Ne(10e^-)$ — equal.
$Cl^-(18e^-)$, $Ar(18e^-)$ — equal.
$Al^{3+}(10e^-)$, $F^-(10e^-)$ — equal.
All three pairs are iso-electronic, so the correct answer is 'all of the above'.

14. **C.** 2.55 eV

**Explanation:** $E_2 = \frac{-13.6}{4} = -3.4\,\text{eV}$; $E_4 = \frac{-13.6}{16} = -0.85\,\text{eV}$.
Absorbed energy $= E_4 - E_2 = -0.85 - (-3.4) = 2.55\,\text{eV}$.

15. **A.** 12 **minutes**

**Explanation:** $\frac{1}{32} = \left(\frac{1}{2}\right)^5 \Rightarrow n = 5$ half-lives.
$t_{1/2} = \dfrac{60}{5} = 12$ minutes.

16. **D.** $7\,\alpha, 4\,\beta$

**Explanation:** $\Delta A = 235 - 207 = 28 \Rightarrow \alpha = \dfrac{28}{4} = 7$.
With only $\alpha$ emission, the atomic number would be $92 - 2(7) = 78$; the actual $Z = 82$, so $\beta = 82 - 78 = 4$.

17. **A.** $1.26 \times 10^{-17}$ M

**Explanation:** $Ag_2S \rightleftharpoons 2Ag^+ + S^{2-}$; $K_{sp} = (2S)^2(S) = 4S^3$.
$S = \left(\dfrac{8 \times 10^{-51}}{4}\right)^{1/3} \approx 1.26 \times 10^{-17}\,\text{M}$.

18. **A.** $Mn^{2+}$ **is higher**

**Explanation:** $Mn^{2+} = [Ar]3d^5$, unpaired electrons = 5, $\mu = \sqrt{5 \times 7} = 5.92$ BM.
$Cr^{3+} = [Ar]3d^3$, unpaired electrons = 3, $\mu = \sqrt{3 \times 5} = 3.87$ BM.
Therefore $Mn^{2+}$ has both more unpaired electrons and stronger magnetism.

19. **C.** 12.35

**Explanation:** $Ca(OH)_2 \rightleftharpoons Ca^{2+} + 2OH^-$;
$K_{sp} = 4S^3 \Rightarrow S = \left(\dfrac{5.5 \times 10^{-6}}{4}\right)^{1/3} \approx 0.0111\,\text{M}$.
$[OH^-] = 2S = 0.0222\,\text{M} \Rightarrow \text{pOH} = -\log(0.0222) \approx 1.65$.
$\text{pH} = 14 - 1.65 = 12.35$.

**C. By Heisenberg's uncertainty principle, the calculated minimum kinetic energy is far greater than the actual nuclear binding**

20. **energy**

**Explanation:** Applying Heisenberg's uncertainty principle to a nuclear radius ($\sim 10^{-15}$ m), the minimum kinetic energy of a confined electron comes out to several thousand MeV, while the actual nuclear binding energy is only a few MeV per nucleon — this mismatch proves an electron cannot be confined within the nucleus.

21. **D. Iso-electronic**

**Explanation:** CO: $6 + 8 = 14$ electrons; $CN^-$: $6 + 7 + 1 = 14$ electrons; $N_2$: $7 + 7 = 14$ electrons.
Since each species has the same total number of electrons, they are iso-electronic with one another.

22. **C.** $K_{sp} = 108S^5$

**Explanation:** $M_3X_2 \rightleftharpoons 3M^{2+} + 2X^{3-}$;
$[M^{2+}] = 3S$, $[X^{3-}] = 2S$.
$K_{sp} = (3S)^3(2S)^2 = 27S^3 \times 4S^2 = 108S^5$.

23. **B.** 1459 nm

**Explanation:** In the Brackett series, $n_1 = 4$. At the series limit, $n_2 = \infty$: $\frac{1}{\lambda} = \frac{R_H}{4^2}$
$\lambda = \frac{16}{R_H} \approx 1.459 \times 10^{-6}\,\text{m} = 1459\,\text{nm}$.

24. **D.** 4.761 Å

**Explanation:** $r_n = r_1 \times n^2$; $r_3 = 0.529 \times 3^2 = 0.529 \times 9 = 4.761$ Å.

25. **D.** 1094 nm**, Paschen series**

**Explanation:** A transition down to $n_2 = 3$ produces the Paschen series.

$\frac{1}{\lambda} = R_H\left(\frac{1}{3^2} - \frac{1}{6^2}\right) = 1.09678 \times 10^7(0.1111 - 0.0278)$

$\lambda \approx 1.094 \times 10^{-6}\,\text{m} = 1094\,\text{nm}$.

26. **A.** $1.98 \times 10^{-12}$ m

**Explanation:** $\lambda = \frac{h}{m_p v} = \frac{6.626\times10^{-34}}{1.67\times10^{-27}\times2\times10^5}$

$\lambda \approx 1.98 \times 10^{-12}$ m.

27. **B.** $4 \times 10^{-8}$

**Explanation:** $CuBr \rightleftharpoons Cu^+ + Br^-$; $K_{sp} = S^2 = (2 \times 10^{-4})^2 = 4 \times 10^{-8}$.

28. **C.** 172.97 g

**Explanation:** At 50°C, 185 g of solution contains 85 g of salt.

In 500 g of solution, salt $= \frac{85}{185} \times 500 = 229.7$ g ; solvent = 270.3 g.

At 10°C, the capacity of that solvent $= \frac{21}{100} \times 270.3 = 56.76$ g.

Precipitated salt $= 229.7 - 56.76 \approx 172.97$ g.

29. **C.** $8.9 \times 10^{-4}$ M

**Explanation:** $Zr_3(PO_4)_4 \rightleftharpoons 3Zr^{4+} + 4PO_4^{3-}$; $[Zr^{4+}] = 3S$, $[PO_4^{3-}] = 4S$.

$K_{sp} = (3S)^3(4S)^4 = 27S^3 \times 256S^4 = 6912S^7 = 3.1 \times 10^{-18}$

$S = \left(\frac{3.1 \times 10^{-18}}{6912}\right)^{1/7} \approx 8.9 \times 10^{-4}$ M.

30. **B.** $4.8 \times 10^{-9}$ g

**Explanation:** $K_{sp} = 27S^4 = 1.09 \times 10^{-36} \Rightarrow$

$S = \left(\frac{1.09 \times 10^{-36}}{27}\right)^{1/4} \approx 4.48 \times 10^{-10}$ M.

In 0.1 L, moles $= 4.48 \times 10^{-11}$ mol; mass $= 4.48 \times 10^{-11} \times 106.9 \approx 4.8 \times 10^{-9}$ g.

31. **A.** $CaCO_3$

**Explanation:** An ionic compound is soluble in water when its hydration enthalpy exceeds its lattice enthalpy. $CaCO_3$ has a very high lattice energy that exceeds its hydration energy, so it remains insoluble in water.

32. **D.** $NH_4Cl$, $(NH_4)_2CO_3$

**Explanation:** Both $NH_4Cl$ and $(NH_4)_2CO_3$ supply the $NH_4^+$ ion, which acts as a common ion (for example, used to suppress the dissociation of $NH_4OH$).

33. **D. It drives the mobile phase quickly under high pressure, giving fast separation and high resolving power**

**Explanation:** In HPLC, high pressure is applied to drive the solvent quickly through a very fine-grained stationary phase, enabling fast separation with high resolving power.

34. **D. Chocolate brown and deep blue (Prussian blue)**

**Explanation:** $Cu^{2+}$ gives a chocolate brown precipitate ($Cu_2[Fe(CN)_6]$) with potassium ferrocyanide.

$Fe^{3+}$ gives a deep blue (Prussian blue, $Fe_4[Fe(CN)_6]_3$) precipitate with potassium ferrocyanide.

35. **B.** 6**;** $m = -1, 0, +1$

**Explanation:** $l = 1$ means a p-subshell, with possible $m = -1, 0, +1$ (3 orbitals), each holding 2 electrons, giving a maximum of 6.

36. **D.** $Z = 28$**, nickel**

**Explanation:** Writing out $1s^22s^22p^63s^23p^64s^23d^8$, the total number of electrons $= 2 + 2 + 6 + 2 + 6 + 2 + 8 = 28$.

The atomic number $Z = 28$, which is nickel ( Ni).

37. **B. Hund's rule**

**Explanation:** Hund's rule of maximum multiplicity states that electrons in degenerate orbitals first occupy them singly with parallel spins, which gives maximum stability.

Hence in nitrogen's $2p^3$, the three electrons occupy separate orbitals with parallel spins.

38. **C.** $m = 0$

**Explanation:** $Mg = [Ne]3s^2$; the outer electron is in the 3s subshell, where $l = 0$. For $l = 0$, the only possible value is $m = 0$.

39. **D.** $n = 3, l = 1, m = -1, s = +\frac{1}{2}$

**Explanation:** Cl(17) = $1s^2 2s^2 2p^6 3s^2 3p^5$; the $3p^5$ distribution is: $3p_x^2\ 3p_y^2\ 3p_z^1$.
The unpaired electron is in the $3p_z$ orbital, i.e. $n = 3, l = 1, m = -1$ (last orbital, opposite spin), $s = +\frac{1}{2}$.

40. **D.** $^{32}_{15}P$

**Explanation:** The isotope $^{32}_{15}P$ is used in treating polycythemia-related anemia and in studying DNA/RNA structure.

41. **D. Hydrogen ($^1H$)**

**Explanation:** MRI imaging uses the spin of the proton or hydrogen nucleus ($^1H$) present in the abundant water molecules of the human body, because $^1H$'s nucleus has an odd number of nucleons, making it NMR active.

42. **B. Vacuum distillation**

**Explanation:** Liquids that decompose at their normal boiling point under high heat are separated by lowering the boiling point at reduced pressure, using the vacuum distillation method.

43. **A.** $n = 3, l = 1, m = +1, s = -\frac{1}{2}$

**Explanation:** $S(16) + 2e^- \rightarrow S^{2-} = 1s^2 2s^2 2p^6 3s^2 3p^6$; $3p^6$ is completely filled. By Hund's rule, the last (6th) electron completes the pairing, entering the $m = +1$ orbital with opposite spin: $n = 3, l = 1, m = +1, s = -\frac{1}{2}$.

44. **C.** $Na_2SO_4$

**Explanation:** A white precipitate with $BaCl_2$ that is insoluble in HCl indicates the presence of the $SO_4^{2-}$ ion (forming $BaSO_4$). A golden yellow flame indicates the presence of the $Na^+$ ion. Hence the salt is $Na_2SO_4$.

45. **B.** $2916s^8$

**Explanation:** $K_3[Na_3(AlF_6)_2] \rightleftharpoons 3K^+ + 3Na^+ + 2AlF_6^{3-}$; $[K^+] = 3s$, $[Na^+] = 3s$, $[AlF_6^{3-}] = 2s$.
$K_{sp} = (3s)^3(3s)^3(2s)^2 = 27s^3 \times 27s^3 \times 4s^2 = 2916s^8$.

**B. Evaporation makes the solution supersaturated, causing salt to crystallize**

46. **out**

**Explanation:** As sunlight evaporates the water, the amount of solvent decreases and the solution gradually becomes saturated and then supersaturated, so the salt exceeds the solution's holding capacity and crystallizes out — this is the basic principle of salt separation.

**A. When the gas reacts chemically with the**

47. **solvent**

**Explanation:** Henry's law applies only when the gas does not react chemically with the solvent and merely undergoes physical dissolution. If the gas reacts with the solvent (as with $NH_3 + H_2O$), the law does not apply.

48. **B.** $\lambda = \dfrac{h}{mv}$

**Explanation:** The de Broglie equation expresses the wave-particle duality of matter: $\lambda = \dfrac{h}{mv}$, where $m$ is mass and $v$ is velocity.

**B. The difference in boiling point (more or**

49. **less than** $25°C$**)**

**Explanation:** If the boiling point difference between two liquids is more than 25°C, ordinary distillation suffices; but if the difference is smaller (close boiling points), fractional distillation is needed.

**A. It fails to explain the fine spectra of**

50. **multi-electron atoms**

**Explanation:** Although the Bohr model successfully explains the spectra of one-electron species like hydrogen, it fails to explain the fine spectra of multi-electron atoms and the Zeeman effect — this is one of its main limitations.