Engineering Daily Exam 11 [Home Practice] EV - Answer Sheet

Syllabus: Qualitative Chemistry

Total Marks: 50 **Negative Marks:** 0.25 **Time:** 1 Hour

MCQ 50 marks

1. **A.** Fe^{2+} **has 4,** Fe^{3+} **has 5**
Explanation: $Fe^{2+} = [Ar]3d^6$ (one pair, remaining 4 unpaired) $\Rightarrow$ unpaired = 4.
$Fe^{3+} = [Ar]3d^5$ (one electron in each orbital) $\Rightarrow$ unpaired = 5, giving $\mu = \sqrt{5 \times 7} = 5.92\,BM$ — Fe^{3+} has stronger magnetism due to the half-filled $3d^5$.

2. **A. Since** l **ranges from** 0 **to** $(n-1)$**, neither** $l = 3$ **at** $n = 3$ **nor** $l = 2$ **at** $n = 2$ **is possible**
Explanation: The maximum value of l is $(n-1)$. At $n = 3$, the maximum is $l = 2$ (d), so 3f ($l = 3$) is impossible.
At $n = 2$, the maximum is $l = 1$ (p), so 2d ($l = 2$) is impossible.

3. **B.** $Cr : [Ar]3d^5 4s^1$ **and** $Cu : [Ar]3d^{10}4s^1$
Explanation: Cr and Cu deviate from the expected $(n + l)$ order ($3d^4 4s^2$ and $3d^9 4s^2$), instead adopting $3d^5 4s^1$ and $3d^{10}4s^1$ respectively, due to extra stability from a half-filled/fully filled d-subshell.

4. **A.** $3d < 4p < 5s < 4f$
Explanation: $(n + l)$ values: 3d = 5; 4p = 5; 5s = 5; 4f = 7.
Among the equal $(n + l) = 5$, the smaller n fills first: $3d(n = 3) < 4p(n = 4) < 5s(n = 5)$; 4f comes last.

5. **D.** $n = 3, l = 3, m = 0, s = +\frac{1}{2}$
Explanation: For $n = 3$, l can be at most 2; $l = 3$ is impossible.
Therefore the set $(n = 3, l = 3, m = 0, s = +\frac{1}{2})$ is not allowed.

6. **C.** $l = 4$**; 9 orbitals; 18 electrons**
Explanation: For a g-subshell, $l = 4$.
Number of orbitals $= 2l + 1 = 2(4) + 1 = 9$.
Maximum electrons $= 2(2l + 1) = 18$.

7. **B.** $\frac{256}{81}$
Explanation: $r_n \propto n^2$, so area $A = \pi r^2 \propto n^4$.
$\frac{A_4}{A_3} = \left(\frac{4}{3}\right)^4 = \frac{256}{81}$.

8. **C.** $(1, 0, 0, +\frac{1}{2}), (1, 0, 0, -\frac{1}{2}), (2, 0, 0, +\frac{1}{2})$
Explanation: $Li = 1s^2 2s^1$. The two 1s electrons share $n = 1, l = 0, m = 0$ but have opposite spins: $(1, 0, 0, +\frac{1}{2})$ and $(1, 0, 0, -\frac{1}{2})$.
The third electron is in 2s: $(2, 0, 0, +\frac{1}{2})$.

9. **A.** $\frac{x}{2}$
Explanation: $v_n = v_0 \times \frac{Z}{n}$; for He^+, $v_1 = v_0 \times \frac{2}{1} = x \Rightarrow v_0 = \frac{x}{2}$.
For Li^{2+}, $v_3 = v_0 \times \frac{3}{3} = v_0 = \frac{x}{2}$.

10. **D. The solution is supersaturated and a precipitate will form**
Explanation: The ionic product (K_{ip}) exceeding the solubility product (K_{sp}) means the ion concentration exceeds the solution's holding capacity; the solution becomes supersaturated and the excess precipitates out.

11. **C. Vacuum distillation**
Explanation: Heat-sensitive liquids that decompose at high temperatures are safely separated by lowering the boiling point at reduced (lower) pressure, using vacuum distillation.

12. **D.** ${}^{14}_{6}C$
Explanation: The radioactive carbon-14 (${}^{14}_{6}C$) isotope, with a half-life of about 5730 years, is used to determine the age of ancient fossils.

13. **D. To detect the point of** α**-particle collision via fluorescence**
Explanation: ZnS (zinc sulfide) is a fluorescent material that produces a visible flash of light when struck by an α-particle. This allowed the deflection (scattering) of α-particles to be observed, proving the existence of the nucleus.

14. **A.** $8\,\alpha, 6\,\beta$
Explanation: $\Delta A = 238 - 206 = 32 \Rightarrow \alpha = \frac{32}{4} = 8$.
With only α emission, Z would be $92 - 2(8) = 76$; the actual $Z = 82$, so $\beta = 82 - 76 = 6$.

15. A. $MgSO_4$

Explanation: A white $BaSO_4$ precipitate insoluble in HCl indicates the presence of SO_4^{2-}.

Na^+ gives golden yellow, Ca^{2+} gives brick-red, and K^+ gives a light violet colour — all three give distinct characteristic flame colours. Mg^{2+}, however, has no characteristic flame colour (it cannot be identified by flame test). So the correct answer is $MgSO_4$. (Note: the original source's marked answer of K_2SO_4 is incorrect — K^+'s light violet colour is a recognized characteristic flame colour.)

16. C. 15 **minutes**

Explanation: $\frac{1}{64} = \left(\frac{1}{2}\right)^6 \Rightarrow n = 6$ half-lives.

$t_{1/2} = \dfrac{90}{6} = 15$ minutes.

17. B. 3.98×10^{-2} M

Explanation: $Cr_2S_3 \rightleftharpoons 2Cr^{3+} + 3S^{2-}$; $K_{sp} = (2S)^2(3S)^3 = 108S^5$.

$S = \left(\dfrac{1.08 \times 10^{-5}}{108}\right)^{1/5} \approx 3.98 \times 10^{-2}$ M.

18. B. 43.1 g

Explanation: At 60°C, 145 g of solution contains 45 g of salt.

In 250 g of solution, salt $= \dfrac{45}{145} \times 250 \approx 77.59$ g ; solvent ≈ 172.41 g.

At 20°C, the capacity $= \dfrac{20}{100} \times 172.41 \approx$ 34.48 g.

Crystallized $= 77.59 - 34.48 \approx 43.1$ g.

19. D. Adding NH_4OH

Explanation: In excess NH_4OH, $Zn(OH)_2$ dissolves to form the soluble complex ion $[Zn(NH_3)_4]^{2+}$, but $Al(OH)_3$ does not dissolve in ammonia (remains insoluble). This allows the two ions to be distinguished.

20. A. Turnbull's blue (deep blue)

Explanation: $K_3[Fe(CN)_6]$ (ferricyanide, containing Fe^{3+}) reacts with the Fe^{2+} ion to form a deep blue precipitate called Turnbull's Blue — a different reagent pairing from Prussian Blue (formed from Fe^{3+} +ferrocyanide), though chemically identical.

A. To suppress the OH^- **concentration via**
21. the common ion effect

Explanation: Adding NH_4Cl suppresses the dissociation of NH_4OH via the common ion (NH_4^+) effect, keeping $[OH^-]$ low. This causes only the low-K_{sp} Group-3 hydroxides to precipitate, while the more soluble Group-4/5 cations do not.

22. B. 486.3 nm

Explanation: $n_1 = 2, n_2 = 4$ (Balmer series): $\frac{1}{\lambda} = R_H\left(\frac{1}{4} - \frac{1}{16}\right)$

$\lambda \approx 4.863 \times 10^{-7}$ m = 486.3 nm.

23. C. 102.6 nm

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

$\lambda \approx 1.026 \times 10^{-7}$ m = 102.6 nm.

24. D. 12 g

Explanation: 25 g of solution contains 5 g of solute, so solvent = 25 − 5 = 20 g.

In 100 g of solution, solute $= \dfrac{5 \times 100}{25} = 20$ g, solvent = 100 − 20 = 80 g.

With solubility 40, the solute needed to saturate is m: $40 = \dfrac{m}{80} \times 100 \Rightarrow m = 32$ g.

Currently there is 20 g, so 32 − 20 = 12 g must be added.

25. A. 6.41 nm**, X-ray/UV border region**

Explanation: For Be^{2+}, Z = 4; $E = 13.6Z^2\left(\frac{1}{1^2} - \frac{1}{3^2}\right) = 13.6(16)(0.889) \approx 193.4$ eV.

$\lambda = \dfrac{1240}{193.4} \approx 6.41$ nm, which falls in the deep UV/X-ray border region — energy gaps widen rapidly in higher-Z hydrogen-like ions.

26. C. 12.75 eV

Explanation: $E_1 = -13.6$ eV, $E_4 = \frac{-13.6}{16} = -0.85$ eV.

Absorbed energy $= E_4 - E_1 = -0.85 - (-13.6) = 12.75$ eV.

27. D. $\frac{1}{4}$

Explanation: $v_n = \dfrac{v_1}{n}$; $v_4 = \dfrac{v_1}{4}$, i.e. $\frac{1}{4}$ of the velocity in the 1st orbit.

28. A. $7.91 \times 10^{-10}\,\text{m}$

Explanation: $\lambda = \dfrac{h}{m_n v} = \dfrac{6.626 \times 10^{-34}}{1.675 \times 10^{-27} \times 500}$ $\lambda \approx 7.91 \times 10^{-10}\,\text{m}$.

29. B. $9.22 \times 10^{-9}\,\text{M}$

Explanation: $AgI \rightleftharpoons Ag^+ + I^-$; $K_{sp} = S^2 \Rightarrow S = \sqrt{8.5 \times 10^{-17}} \approx 9.22 \times 10^{-9}\,\text{M}$.

30. C. No, precipitation will not occur

Explanation: After mixing, $[Pb^{2+}] = 0.025\,\text{M}$, $[Cl^-] = 0.025\,\text{M}$.
$K_{ip} = [Pb^{2+}][Cl^-]^2 = 0.025 \times (0.025)^2 = 1.56 \times 10^{-5}$.
Since $K_{ip}(1.56 \times 10^{-5}) < K_{sp}(1.7 \times 10^{-5})$, the solution remains unsaturated and no precipitate forms.

31. D. $K_{sp} = 108S^5$

Explanation: $Mg_3(PO_4)_2 \rightleftharpoons 3Mg^{2+} + 2PO_4^{3-}$; $[Mg^{2+}] = 3S$, $[PO_4^{3-}] = 2S$.
$K_{sp} = (3S)^3(2S)^2 = 27S^3 \times 4S^2 = 108S^5$.

32. B. $1.6 \times 10^{24}\,\text{eV/mol}$

Explanation: The M shell means $n = 3$; for He^+, $Z = 2$.
$E = 13.6\left(\frac{1}{3^2} - \frac{1}{4^2}\right) \times 2^2 = 13.6 \times 0.0486 \times 4 \approx 2.65\,\text{eV}$.
Per mole (multiplying by Avogadro's number): $E \times N_A \approx 1.6 \times 10^{24}\,\text{eV/mol}$.

33. B. $\frac{\pi}{2}$ **(i.e.** $90°$**)**

Explanation: The three axes (x, y, z) of p-orbitals are mutually perpendicular, i.e. each pair is at an angle of $90°$ or $\frac{\pi}{2}$ radians.

34. C. $\frac{9}{16}$

Explanation: $E_n = \dfrac{-E_0 Z^2}{n^2}$; $\dfrac{E_4}{E_3} = \dfrac{-E_0/16}{-E_0/9} = \dfrac{9}{16}$.

35. D. It will increase by $\frac{16}{9}r_3$

Explanation: $r_n \propto n^2$; $\dfrac{r_5}{r_3} = \dfrac{25}{9}$, i.e. $r_5 = \dfrac{25}{9}r_3$.
Increase $= r_5 - r_3 = \left(\dfrac{25}{9} - 1\right) r_3 = \dfrac{16}{9}r_3$.

36. C. 1

Explanation: The number of angular (axial) nodes = l. For 3p, $l = 1$, so there is 1 angular node.

37. D. 42

Explanation: $Mo(42) \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^5 5s^1$; in this exceptional configuration, the total number of electrons = 42, so $Z = 42$.

38. C. 50

Explanation: Total electrons in HSO_4^- = $(1 + 16 + 8 \times 4 + 1) = 1 + 16 + 32 + 1 = 50$ (H: 1, S: 16, 4 O atoms at 8 each = 32, plus +1 for the extra negative charge).

39. C. 39

Explanation: With a charge of -1 and 18 electrons, the ion has one more electron than protons, so the number of protons = $18 - 1 = 17$.
Mass number = protons + neutrons = $17 + 22 = 39$.

40. D. Neutron

Explanation: Among the three stable fundamental particles of an atom, the neutron is charge-neutral. Having no charge, a neutron cannot be affected or accelerated by an electromagnetic field.

41. B. $^{20}_{11}Na$

Explanation: In β emission, mass number stays the same and atomic number increases by 1: $^{24}_{12}Mg \xrightarrow{-\beta} {}^{24}_{13}Al\,(X)$.
In α emission, mass number decreases by 4 and atomic number by 2: $^{24}_{13}Al \xrightarrow{-\alpha} {}^{20}_{11}Na\,(Y)$.

42. A. $1.008 \times 10^{-3}\,\text{kg}$

Explanation: $m = (1.6749 \times 10^{-27}\,\text{kg}) \times (6.022 \times 10^{23}) \approx 1.0086 \times 10^{-3}\,\text{kg}$.

43. A. $\sqrt{6}\,\hbar$

Explanation: $L = \sqrt{l(l+1)}\,\hbar$; for a d-orbital, $l = 2$.
$L = \sqrt{2(2+1)}\,\hbar = \sqrt{6}\,\hbar$.

44. B. Dirty green

Explanation: $Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2\downarrow$; $Fe(OH)_2$ first forms as a dirty green precipitate, which slowly oxidizes in air to become reddish-brown $Fe(OH)_3$.

B. Bond vibration and rotational
45. **transitions**

Explanation: Absorbed infrared (IR) radiation causes transitions between vibrational and rotational energy levels of molecular bonds, which is the fundamental basis of IR spectroscopy.

46. **A.** 7.063

Explanation: $Al(OH)_3 \rightleftharpoons Al^{3+} + 3OH^-$; taking the fraction dissociated as 0.12, $[Al^{3+}] = 0.12S$, $[OH^-] = 0.36S$.
$K_{sp} = (0.12S)(0.36S)^3 = 2 \times 10^{-32} \Rightarrow S \approx 43.47 \times 10^{-9}$ M.
$[OH^-] = 0.36S + 10^{-7} \approx 1.664 \times 10^{-8} + 10^{-7}$; $pOH = -\log[OH^-]$; $pH = 14 - pOH \approx 7.063$.

47. **D. Ultraviolet (UV)**

Explanation: Earth's ozone layer absorbs most of the harmful ultraviolet (UV) radiation from the sun, protecting living organisms.

B. All four quantum numbers being
48. **identical**

Explanation: According to Pauli's exclusion principle, no two electrons in an atom can have all four quantum numbers (n, l, m, s) identical at the same time.

49. **B. In order of increasing energy**

Explanation: According to the Aufbau principle, electrons fill orbitals starting from the lowest energy orbital and progressing to successively higher-energy orbitals.

C. γ-ray > X-ray > Visible light > Radio
50. **wave**

Explanation: $E \propto \frac{1}{\lambda}$; the wavelength order is γ-ray < X-ray < UV < Visible < IR < Microwave < Radio.
So the energy order is reversed: γ-ray > X-ray > Visible light > Radio wave.