

AIPMT 2010 Prelims — Chemistry Question Paper with Solutions

43 Chemistry questions as set in the paper · answers checked by RankUp

AIPMT 2010 Prelims · Q51

1. An increase in equivalent conductance of a strong electrolyte with dilution is mainly due to

- (A) Increase in number of ions
- (B) Increase in ionic mobility of ions
- (C) 100% ionisation of electrolyte at normal dilution
- (D) Increase in both i.e. number of ions and ionic mobility of ions

AIPMT 2010 Prelims · Q52

2. 25.3 g of sodium carbonate, Na_2CO_3 is dissolved in enough water to make 250 mL of solution. If sodium carbonate dissociates completely, molar concentration of sodium ion, Na^+ and carbonate ions, CO_3^{2-} are respectively (Molar mass of $\text{Na}_2\text{CO}_3 = 106 \text{ g mol}^{-1}$)

- (A) 0.477 M and 0.477 M
- (B) 0.955 M and 1.910 M
- (C) 1.910 M and 0.955 M
- (D) 1.90 M and 1.910 M

AIPMT 2010 Prelims · Q53

3. Property of the alkaline earth metals that increases with their atomic number

- (A) Electronegativity
- (B) Solubility of their hydroxides in water
- (C) Solubility of their sulphates in water
- (D) Ionization energy

AIPMT 2010 Prelims · Q54

4. Which of the following pairs has the same size?

- (A) Zn^{2+} , Hf^{4+}
- (B) Fe^{2+} , Ni^{2+}
- (C) Zr^{4+} , Ti^{4+}
- (D) Zr^{4+} , Hf^{4+}

AIPMT 2010 Prelims · Q55

5. In a buffer solution containing equal concentration of B^- and HB , the K_b for B^- is 10^{-10} . The pH of buffer solution is

- (A) 4
- (B) 10
- (C) 7
- (D) 6

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6. An aqueous solution is 1.00 molal in KI. Which change will cause the vapour pressure of the solution to increase?

- (A) Addition of water
- (B) Addition of NaCl
- (C) Addition of Na_2SO_4
- (D) Addition of 1.00 molal KI

7. What is $[H^+]$ in mol/L of a solution that is 0.20 M in CH_3COONa and 0.10 M in CH_3COOH ? K_a for $CH_3COOH = 1.8 \times 10^{-5}$.

- (A) 9.0×10^{-6}
- (B) 3.5×10^{-4}
- (C) 1.1×10^{-5}
- (D) 1.8×10^{-5}

8. For the reaction $N_2O_5(g) \rightarrow 2NO_2(g) + (1/2)O_2(g)$ the value of rate of disappearance of N_2O_5 is given as $6.25 \times 10^{-3} \text{ mol L}^{-1} \text{ s}^{-1}$. The rate of formation of NO_2 and O_2 is given respectively as:

- (A) $1.25 \times 10^{-2} \text{ mol L}^{-1} \text{ s}^{-1}$ and $6.25 \times 10^{-3} \text{ mol L}^{-1} \text{ s}^{-1}$
- (B) $6.25 \times 10^{-3} \text{ mol L}^{-1} \text{ s}^{-1}$ and $6.25 \times 10^{-3} \text{ mol L}^{-1} \text{ s}^{-1}$
- (C) $1.25 \times 10^{-2} \text{ mol L}^{-1} \text{ s}^{-1}$ and $3.125 \times 10^{-3} \text{ mol L}^{-1} \text{ s}^{-1}$
- (D) $6.25 \times 10^{-3} \text{ mol L}^{-1} \text{ s}^{-1}$ and $3.125 \times 10^{-3} \text{ mol L}^{-1} \text{ s}^{-1}$

9. Standard entropies of X_2 , Y_2 and XY_3 are 60, 40 and $50 \text{ J K}^{-1} \text{ mol}^{-1}$ respectively. For the reaction $(1/2)X_2 + (3/2)Y_2 \rightleftharpoons XY_3$, $\Delta H = -30 \text{ kJ}$ to be at equilibrium, the temperature should be

- (A) 500 K
- (B) 750 K
- (C) 1000 K
- (D) 1250 K

10. During the kinetic study of the reaction $2A + B \rightarrow C + D$, following results were obtained:

Run I: $[A] = 0.1$, $[B] = 0.1$, rate = 6.0×10^{-3}

Run II: $[A] = 0.3$, $[B] = 0.2$, rate = 7.2×10^{-2}

Run III: $[A] = 0.3$, $[B] = 0.4$, rate = 2.88×10^{-1}

Run IV: $[A] = 0.4$, $[B] = 0.1$, rate = 2.40×10^{-2}

($[A]$, $[B]$ in mol L^{-1} ; initial rate of formation of D in $\text{mol L}^{-1} \text{ min}^{-1}$)

Based on the above data which one of the following is correct?

- (A) rate = $k[A][B]^2$
- (B) rate = $k[A]^2[B]$
- (C) rate = $k[A][B]$
- (D) rate = $k[A]^2[B]^2$

11. For the reduction of silver ions with copper metal, the standard cell potential was found to be +0.46 V at 25°C. The value of standard Gibbs energy, ΔG° will be (F = 96500 C mol⁻¹)

- (A) -98.0 kJ
- (B) -89.0 kJ
- (C) -89.0 J
- (D) -44.5 kJ

12. Which one of the following species does not exist under normal conditions?

- (A) Li_2
- (B) Be_2^+
- (C) Be_2
- (D) B_2

13. AB crystallizes in a body centred cubic lattice with edge length 'a' equal to 387 pm. The distance between two oppositely charged ions in the lattice is

- (A) 300 pm
- (B) 335 pm
- (C) 250 pm
- (D) 200 pm

14. Which one of the following ions has electronic configuration [Ar]3d⁶? (At. nos. Mn = 25, Fe = 26, Co = 27, Ni = 28)

- (A) Co³⁺
- (B) Ni³⁺
- (C) Mn³⁺
- (D) Fe³⁺

15. In which of the following equilibrium K_c and K_p are not equal?

- (A) $2\text{C(s)} + \text{O}_2\text{(g)} \rightleftharpoons 2\text{CO(g)}$
- (B) $2\text{NO(g)} \rightleftharpoons \text{N}_2\text{(g)} + \text{O}_2\text{(g)}$
- (C) $\text{SO}_2\text{(g)} + \text{NO}_2\text{(g)} \rightleftharpoons \text{SO}_3\text{(g)} + \text{NO(g)}$
- (D) $\text{H}_2\text{(g)} + \text{I}_2\text{(g)} \rightleftharpoons 2\text{HI(g)}$

16. If pH of a saturated solution of Ba(OH)₂ is 12, the value of its K_{sp} is

- (A) $5.00 \times 10^{-7} \text{ M}^3$
- (B) $4.00 \times 10^{-6} \text{ M}^3$
- (C) $4.00 \times 10^{-7} \text{ M}^3$
- (D) $5.00 \times 10^{-6} \text{ M}^3$

17. Which of the following ions will exhibit colour in aqueous solutions?

- (A) Sc³⁺ (Z = 21)
- (B) La³⁺ (Z = 57)
- (C) Ti³⁺ (Z = 22)
- (D) Lu³⁺ (Z = 71)

18. Which one of the following compounds is a peroxide?

- (A) NO₂
- (B) KO₂
- (C) BaO₂
- (D) MnO₂

19. In which of the following pairs of molecules/ions, the central atoms have sp² hybridization?

- (A) BF₃ and NH₂⁻
- (B) NO₂⁻ and NH₃
- (C) BF₃ and NO₂⁻
- (D) NH₂⁻ and H₂O

20. The correct order of the decreasing ionic radii among the following isoelectronic species is

- (A) K⁺ > Ca²⁺ > Cl⁻ > S²⁻
- (B) Ca²⁺ > K⁺ > S²⁻ > Cl⁻
- (C) Cl⁻ > S²⁻ > Ca²⁺ > K⁺
- (D) S²⁻ > Cl⁻ > K⁺ > Ca²⁺

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21. The number of atoms in 0.1 mol of a triatomic gas is ($N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$)

- (A) 1.800×10^{22}
- (B) 6.026×10^{22}
- (C) 1.806×10^{23}
- (D) 3.600×10^{23}

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22. Which of the following alkaline earth metal sulphates has hydration enthalpy higher than the lattice enthalpy?

- (A) SrSO_4
- (B) CaSO_4
- (C) BeSO_4
- (D) BaSO_4

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23. The existence of two different coloured complexes with the composition of $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$ is due to

- (A) Ionization isomerism
- (B) Linkage isomerism
- (C) Geometrical isomerism
- (D) Coordination isomerism

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24. Oxidation states of P in $\text{H}_4\text{P}_2\text{O}_5$, $\text{H}_4\text{P}_2\text{O}_6$, $\text{H}_4\text{P}_2\text{O}_7$, are respectively

- (A) +3, +4, +5
- (B) +3, +5, +4
- (C) +5, +3, +4
- (D) +5, +4, +3

AIPMT 2010 Prelims · Q78

25. The tendency of BF_3 , BCl_3 and BBr_3 to behave as Lewis acid decreases in the sequence

- (A) $\text{BF}_3 > \text{BCl}_3 > \text{BBr}_3$
- (B) $\text{BCl}_3 > \text{BF}_3 > \text{BBr}_3$
- (C) $\text{BBr}_3 > \text{BCl}_3 > \text{BF}_3$
- (D) $\text{BBr}_3 > \text{BF}_3 > \text{BCl}_3$

AIPMT 2010 Prelims · Q79

26. Which of the following represents the correct order of increasing electron gain enthalpy with negative sign for the elements O, S, F and Cl?

- (A) $\text{S} < \text{O} < \text{Cl} < \text{F}$
- (B) $\text{Cl} < \text{F} < \text{O} < \text{S}$
- (C) $\text{O} < \text{S} < \text{F} < \text{Cl}$
- (D) $\text{F} < \text{S} < \text{O} < \text{Cl}$

AIPMT 2010 Prelims · Q80

27. Crystal field stabilization energy for high spin d^4 octahedral complex is

- (A) $-0.6 \Delta_o$
- (B) $-1.8 \Delta_o$
- (C) $-1.6 \Delta_o + P$
- (D) $-1.2 \Delta_o$

28. In which one of the following species the central atom has the type of hybridisation which is not the same as that present in the other three?

- (A) PCl_5
- (B) SF_4
- (C) I_3^-
- (D) SbCl_5^{2-}

29. Which of the following molecular hydrides acts as a Lewis acid?

- (A) CH_4
- (B) NH_3
- (C) H_2O
- (D) B_2H_6

30. Aniline in a set of the following reactions yielded a coloured product Y: $\text{C}_6\text{H}_5\text{NH}_2 \xrightarrow{(\text{NaNO}_2/\text{HCl}, 273-278 \text{ K})} \text{X} \xrightarrow{(\text{N,N-dimethylaniline})} \text{Y}$

The structure of Y would be

- (A) $\text{CH}_3\text{NH}-\text{C}_6\text{H}_4-\text{N}=\text{N}-\text{C}_6\text{H}_4-\text{NHCH}_3$ (both para)
- (B) $\text{C}_6\text{H}_5-\text{N}=\text{N}-\text{C}_6\text{H}_4-\text{N}(\text{CH}_3)_2$ (para)
- (C) $\text{CH}_3\text{NH}-\text{C}_6\text{H}_4-\text{NH}-\text{C}_6\text{H}_4-\text{NHCH}_3$ (both para)
- (D) $\text{CH}_3-\text{C}_6\text{H}_4-\text{N}=\text{N}-\text{C}_6\text{H}_4-\text{NH}_2$ (both para)

31. The reaction of toluene with Cl_2 in presence of FeCl_3 gives X and reaction in presence of light gives Y. Thus, X and Y are

- (A) X = Benzyl chloride, Y = m-chlorotoluene
- (B) X = Benzal chloride, Y = o-chlorotoluene
- (C) X = m-chlorotoluene, Y = p-chlorotoluene
- (D) X = o- and p-chlorotoluene, Y = Trichloromethyl benzene

32. Liquid hydrocarbons can be converted to a mixture of gaseous hydrocarbons by

- (A) Hydrolysis
- (B) Oxidation
- (C) Cracking
- (D) Distillation under reduced pressure

33. Which of the following is employed as a tranquilizer drug?

- (A) Mifepristone
- (B) Promethazine
- (C) Valium
- (D) Naproxen

34. Which one of the following does not exhibit the phenomenon of mutarotation?

- (A) (-) Fructose
- (B) (+) Sucrose
- (C) (+) Lactose
- (D) (+) Maltose

35. Which of the following structures represents Neoprene polymer?

- (A) $[-\text{CH}(\text{C}_6\text{H}_5)-\text{CH}_2-]_n$
- (B) $[-\text{CH}_2-\text{C}(\text{Cl})=\text{CH}-\text{CH}_2-]_n$
- (C) $[-\text{CH}_2-\text{CH}(\text{CN})-]_n$
- (D) $[-\text{CH}_2-\text{CH}(\text{Cl})-]_n$

36. In a set of reactions, ethyl benzene yielded a product D:
 $\text{C}_6\text{H}_5\text{CH}_2\text{CH}_3 \xrightarrow{(\text{KMnO}_4, \text{KOH})} \text{B} \xrightarrow{(\text{Br}_2, \text{FeCl}_3)} \text{C} \xrightarrow{(\text{C}_2\text{H}_5\text{OH}, \text{H}^+)} \text{D}$
'D' would be

- (A) Ethyl 3-bromobenzoate ($\text{m-Br-C}_6\text{H}_4\text{-COOC}_2\text{H}_5$)
- (B) $\text{C}_6\text{H}_5\text{-CH}_2\text{-CH(Br)-COOC}_2\text{H}_5$
- (C) Ethyl (2,4-dibromophenyl)acetate ($2,4\text{-Br}_2\text{C}_6\text{H}_3\text{-CH}_2\text{COOC}_2\text{H}_5$)
- (D) 3-Ethoxybenzoic acid ($\text{m-CH}_3\text{CH}_2\text{O-C}_6\text{H}_4\text{-COOH}$)

37. Which is most reactive towards $\text{S}_{\text{N}}1$ reaction?

- (A) $\text{C}_6\text{H}_5\text{CH}_2\text{Br}$
- (B) $\text{C}_6\text{H}_5\text{CH(C}_6\text{H}_5\text{)Br}$
- (C) $\text{C}_6\text{H}_5\text{CH(CH}_3\text{)Br}$
- (D) $\text{C}_6\text{H}_5\text{C(CH}_3\text{)(C}_6\text{H}_5\text{)Br}$

38. Which one of the following compounds has the most acidic nature?

- (A) $(\text{C}_6\text{H}_{11})_2\text{CHOH}$ (dicyclohexylmethanol)
- (B) $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$ (benzyl alcohol)
- (C) $\text{C}_6\text{H}_5\text{OH}$ (phenol)
- (D) $\text{C}_6\text{H}_{11}\text{OH}$ (cyclohexanol)

39. Given are cyclohexanol (I), acetic acid (II), 2, 4, 6-trinitrophenol (III) and phenol (IV). In these the order of decreasing acidic character will be

- (A) $\text{III} > \text{IV} > \text{II} > \text{I}$
- (B) $\text{III} > \text{II} > \text{IV} > \text{I}$
- (C) $\text{II} > \text{III} > \text{I} > \text{IV}$
- (D) $\text{II} > \text{III} > \text{IV} > \text{I}$

40. Acetamide is treated with the following reagents separately. Which one of these would yield methyl amine?

- (A) PCl_5
- (B) NaOH-Br_2
- (C) Sodalime
- (D) Hot conc. H_2SO_4

41. Which of the following reactions will not result in the formation of carbon-carbon bonds?

- (A) Friedel-Crafts acylation
- (B) Reimer-Tiemann reaction
- (C) Cannizzaro reaction
- (D) Wurtz reaction

42. Among the given compounds, the most susceptible to nucleophilic attack at the carbonyl group is

- (A) CH_3COCl
- (B) $\text{CH}_3\text{COOCH}_3$
- (C) CH_3CONH_2
- (D) $\text{CH}_3\text{COOCOCH}_3$

43. A solution of sucrose (molar mass = 342 g mol⁻¹) has been prepared by dissolving 68.5 g of sucrose in 1000 g of water. The freezing point of the solution obtained will be (K_f for water = 1.86 K kg mol⁻¹)

- (A) -0.570°C
(B) -0.372°C
(C) -0.520°C
(D) +0.372°C

Answer key and explanations

1. Answer: (B) Increase in ionic mobility of ions

A strong electrolyte is already fully ionised, so dilution does not add ions. Dilution weakens interionic attractions, so the ions move faster: the increase is due to greater ionic mobility. More ions is the explanation for weak electrolytes.

2. Answer: (C) 1.910 M and 0.955 M

Moles = $25.3/106 = 0.2387$ mol in 0.250 L, so $[\text{Na}_2\text{CO}_3] = 0.955$ M. Each formula unit gives 2 Na⁺ and 1 CO₃²⁻, so $[\text{Na}^+] = 1.910$ M and $[\text{CO}_3^{2-}] = 0.955$ M. The reversed pair swaps the ions.

3. Answer: (B) Solubility of their hydroxides in water

Down group 2 the lattice enthalpy of hydroxides falls faster than hydration enthalpy, so hydroxide solubility increases (Be(OH)₂ is insoluble, Ba(OH)₂ is fairly soluble). Sulphate solubility does the opposite and decreases; electronegativity and ionisation energy also decrease.

4. Answer: (D) Zr⁴⁺, Hf⁴⁺

Because of the lanthanoid contraction, Hf (5d) is almost the same size as Zr (4d), so Zr⁴⁺ and Hf⁴⁺ have nearly identical radii. Ti⁴⁺ is a 3d ion and clearly smaller than Zr⁴⁺.

5. Answer: (A) 4

For the buffer B⁻/HB, $\text{pOH} = \text{pK}_b + \log([\text{HB}]/[\text{B}^-])$. With equal concentrations $\text{pOH} = \text{pK}_b = 10$, so $\text{pH} = 14 - 10 = 4$. Answering 10 confuses pOH with pH.

6. Answer: (A) Addition of water

Vapour pressure lowering depends on solute concentration. Adding water dilutes the solution, so its vapour pressure rises. Adding NaCl or Na₂SO₄ adds solute and lowers it; adding more 1.00 molal KI leaves the concentration unchanged.

7. Answer: (A) 9.0×10^{-6}

Buffer: $[\text{H}^+] = K_a[\text{CH}_3\text{COOH}]/[\text{CH}_3\text{COO}^-] = 1.8 \times 10^{-5} \times 0.10/0.20 = 9.0 \times 10^{-6}$ M. 1.8×10^{-5} would hold only if the acid and salt concentrations were equal.

8. Answer: (C) $1.25 \times 10^{-2} \text{ mol L}^{-1} \text{ s}^{-1}$ and $3.125 \times 10^{-3} \text{ mol L}^{-1} \text{ s}^{-1}$

Rate = $-\text{d}[\text{N}_2\text{O}_5]/\text{dt} = \frac{1}{2} \text{d}[\text{NO}_2]/\text{dt} = 2 \text{d}[\text{O}_2]/\text{dt}$. So $\text{d}[\text{NO}_2]/\text{dt} = 2 \times 6.25 \times 10^{-3} = 1.25 \times 10^{-2}$ and $\text{d}[\text{O}_2]/\text{dt} = 6.25 \times 10^{-3}/2 = 3.125 \times 10^{-3} \text{ mol L}^{-1} \text{ s}^{-1}$.

9. Answer: (B) 750 K

$\Delta S^\circ = 50 - (\frac{1}{2} \times 60 + 3/2 \times 40) = 50 - 90 = -40 \text{ J K}^{-1} \text{ mol}^{-1}$. At equilibrium $\Delta G = 0$, so $T = \Delta H/\Delta S = (-30000)/(-40) = 750$ K. Forgetting the stoichiometric halves gives a different ΔS and a wrong T.

10. Answer: (A) rate = $k[\text{A}][\text{B}]^2$

Runs II and III: [A] fixed, [B] doubled, rate $\times 4$, so order in B = 2. Runs I and IV: [B] fixed, [A] $\times 4$, rate $\times 4$, so order in A = 1. Rate = $k[\text{A}][\text{B}]^2$; check: Run II/Run I = $(3 \times 4) = 12 = 7.2 \times 10^{-2}/6.0 \times 10^{-3}$.

11. Answer: (B) -89.0 kJ

$\text{Cu} + 2\text{Ag}^+ \rightarrow \text{Cu}^{2+} + 2\text{Ag}$ involves $n = 2$. $\Delta G^\circ = -nFE^\circ = -2 \times 96500 \times 0.46 = -88780 \text{ J} \approx -89.0 \text{ kJ}$. Taking $n = 1$ gives -44.5 kJ; -89.0 J has the wrong unit.

12. Answer: (C) Be₂

Be₂ has 8 electrons: $\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2$, bond order $(4 - 4)/2 = 0$, so it does not exist. Li₂ (bond order 1), Be₂⁺ (bond order $\frac{1}{2}$) and B₂ (bond order 1) have positive bond orders.

13. Answer: (B) 335 pm

In a body-centred (CsCl-type) AB lattice the oppositely charged ions touch along the body diagonal: $2(r^+ + r^-) = \sqrt{3}a$. Distance = $\sqrt{3} \times 387/2 \approx 335$ pm. Using $a/2$ or $a/\sqrt{2}$ gives the wrong distances.

14. Answer: (A) Co³⁺

Co (Z = 27) is [Ar]3d⁷4s²; removing 3 electrons gives $\text{Co}^{3+} = [\text{Ar}]3d^6$. Fe³⁺ is 3d⁵, Mn³⁺ is 3d⁴ and Ni³⁺ is 3d⁷.

15. Answer: (A) $2\text{C(s)} + \text{O}_2\text{(g)} \rightleftharpoons 2\text{CO(g)}$

$K_p = K_c(RT)^{\Delta n_g}$. For $2\text{C(s)} + \text{O}_2\text{(g)} \rightleftharpoons 2\text{CO(g)}$, only gases count: $\Delta n_g = 2 - 1 = 1$, so $K_p \neq K_c$. In the other three reactions the moles of gas are the same on both sides ($\Delta n_g = 0$).

16. Answer: (A) $5.00 \times 10^{-7} \text{ M}^3$

$\text{pH } 12 \rightarrow \text{pOH } 2 \rightarrow [\text{OH}^-] = 10^{-2} \text{ M}$. Ba(OH)_2 gives s and $2s$, so $s = 5 \times 10^{-3} \text{ M}$. $K_{sp} = s(2s)^2 = 5 \times 10^{-3} \times 10^{-4} = 5.00 \times 10^{-7} \text{ M}^3$. Using $4s^3$ with $s = 10^{-2}$ gives 4×10^{-6} .

17. Answer: (C) Ti^{3+} ($Z = 22$)

Ti^{3+} is $3d^1$ with one unpaired electron, so a d-d transition gives colour (violet). Sc^{3+} ($3d^0$), La^{3+} ($4f^0$) and Lu^{3+} ($4f^{14}$) have no unpaired d/f electrons and are colourless.

18. Answer: (C) BaO_2

BaO_2 contains the peroxide ion O_2^{2-} (O-O single bond). KO_2 is a superoxide (O_2^-), and NO_2 and MnO_2 are ordinary oxides with no O-O bond.

19. Answer: (C) BF_3 and NO_2^-

BF_3 has 3 bond pairs and no lone pair (sp^2); NO_2^- has 2 bond pairs and 1 lone pair on N (sp^2). NH_2^- , NH_3 and H_2O each have 4 electron pairs on the central atom and are sp^3 .

20. Answer: (D) $\text{S}^{2-} > \text{Cl}^- > \text{K}^+ > \text{Ca}^{2+}$

All four ions have 18 electrons. Size falls as nuclear charge rises: S^{2-} ($Z = 16$) $>$ Cl^- (17) $>$ K^+ (19) $>$ Ca^{2+} (20). The orders putting cations first reverse this trend.

21. Answer: (C) 1.806×10^{23}

$0.1 \text{ mol of molecules} \times 3 \text{ atoms} \times 6.02 \times 10^{23} = 1.806 \times 10^{23} \text{ atoms}$. 6.02×10^{22} is the number of molecules, not atoms.

22. Answer: (C) BeSO_4

The small Be^{2+} ion has a very high hydration enthalpy that exceeds the lattice enthalpy of BeSO_4 , so BeSO_4 is soluble. For Ca, Sr and Ba sulphates hydration enthalpy falls below lattice enthalpy, making them sparingly soluble.

23. Answer: (C) Geometrical isomerism

$[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$ is octahedral MA_4B_2 , which exists as cis (violet) and trans (green) isomers: geometrical isomerism. Ionisation and linkage isomerism need different ions or an ambidentate ligand, which are absent here.

24. Answer: (A) +3, +4, +5

With $\text{H} = +1$ and $\text{O} = -2$: $\text{H}_4\text{P}_2\text{O}_5$: $4 + 2x - 10 = 0$, $x = +3$; $\text{H}_4\text{P}_2\text{O}_6$: $x = +4$; $\text{H}_4\text{P}_2\text{O}_7$: $x = +5$. So +3, +4, +5.

25. Answer: (C) $\text{BBr}_3 > \text{BCl}_3 > \text{BF}_3$

Lewis acidity follows how electron-deficient boron remains. Back-donation from the halogen p orbital into boron's empty 2p is strongest for F (similar size 2p-2p) and weakest for Br, so BF_3 is the weakest and BBr_3 the strongest acid: $\text{BBr}_3 > \text{BCl}_3 > \text{BF}_3$. Going by electronegativity alone wrongly gives BF_3 as strongest.

26. Answer: (C) $\text{O} < \text{S} < \text{F} < \text{Cl}$

Negative electron gain enthalpies: $\text{O} \approx 141$, $\text{S} \approx 200$, $\text{F} \approx 328$, $\text{Cl} \approx 349 \text{ kJ/mol}$. O and F are less negative than S and Cl because their small size causes electron repulsion. So $\text{O} < \text{S} < \text{F} < \text{Cl}$.

27. Answer: (A) $-0.6 \Delta_0$

High-spin d^4 in an octahedral field is $t_{2g}^3 e_g^1$. $\text{CFSE} = 3(-0.4\Delta_0) + 1(+0.6\Delta_0) = -0.6\Delta_0$. $-1.6\Delta_0 + P$ is the low-spin t_{2g}^4 value.

28. Answer: (D) SbCl_5^{2-}

PCl_5 (5 bond pairs), SF_4 (4 bp + 1 lp) and I_3^- (2 bp + 3 lp) all have 5 electron pairs: sp^3d . SbCl_5^{2-} has Sb(III) with 5 bond pairs and 1 lone pair, 6 pairs: sp^3d^2 , so it is the odd one out.

29. Answer: (D) B_2H_6

B_2H_6 is electron-deficient (each B has an incomplete octet) and accepts electron pairs, so it acts as a Lewis acid. CH_4 is electron-precise, while NH_3 and H_2O have lone pairs and act as Lewis bases.

30. Answer: (B) $\text{C}_6\text{H}_5\text{-N=N-C}_6\text{H}_4\text{-N(CH}_3)_2$ (para)

Aniline with NaNO_2/HCl at 273–278 K gives benzenediazonium chloride (X). This couples with N,N-dimethylaniline at the para position to give the yellow azo dye p-(dimethylamino)azobenzene, $\text{C}_6\text{H}_5\text{-N=N-C}_6\text{H}_4\text{-N(CH}_3)_2$. The other structures do not contain the unchanged phenyl ring from aniline joined to the dimethylamino ring.

31. Answer: (D) X = o- and p-chlorotoluene, Y = Trichloromethyl benzene

With FeCl_3 (Lewis acid) chlorine substitutes the ring at the o- and p-positions activated by CH_3 , giving o- and p-chlorotoluene (X). In light, free-radical substitution occurs on the side chain; with excess Cl_2 this goes to $\text{C}_6\text{H}_5\text{CCl}_3$, trichloromethylbenzene (Y). Benzyl chloride is a side-chain product, so it cannot be X.

32. Answer: (C) Cracking

Cracking (pyrolysis) breaks large hydrocarbon molecules into smaller ones at high temperature, turning liquid hydrocarbons into gaseous ones. Distillation under reduced pressure only separates components without changing them.

33. Answer: (C) Valium

Valium (diazepam) is a tranquilizer. Mifepristone is an anti-fertility drug, promethazine an antihistamine and naproxen an analgesic/anti-inflammatory.

34. Answer: (B) (+) Sucrose

Mutarotation needs a free hemiacetal/hemiketal group that can open and re-close. In sucrose the anomeric carbons of glucose and fructose are joined in the glycosidic bond, so sucrose is non-reducing and shows no mutarotation. Fructose, lactose and maltose have a free anomeric carbon.

35. Answer: (B) $[-\text{CH}_2-\text{C}(\text{Cl})=\text{CH}-\text{CH}_2-]_n$

Neoprene is polychloroprene, made from chloroprene (2-chloro-1,3-butadiene): $[-\text{CH}_2-\text{C}(\text{Cl})=\text{CH}-\text{CH}_2-]_n$. The $-\text{CH}(\text{C}_6\text{H}_5)-$ polymer is polystyrene, $-\text{CH}(\text{CN})-$ is polyacrylonitrile and $-\text{CH}(\text{Cl})-$ is PVC.

36. Answer: (A) Ethyl 3-bromobenzoate (m-Br- C_6H_4 - COOC_2H_5)

Alkaline KMnO_4 oxidises the whole ethyl side chain to $-\text{COOH}$, so B is benzoic acid. $-\text{COOH}$ is meta-directing, so $\text{Br}_2/\text{FeCl}_3$ gives m-bromobenzoic acid as C. Esterification with ethanol/ H^+ then gives D, ethyl m-bromobenzoate. Products that keep a CH_2 side chain ignore the side-chain oxidation.

37. Answer: (D) $\text{C}_6\text{H}_5\text{C}(\text{CH}_3)(\text{C}_6\text{H}_5)\text{Br}$

$\text{S}_\text{N}1$ rate depends on carbocation stability. $\text{C}_6\text{H}_5\text{C}(\text{CH}_3)(\text{C}_6\text{H}_5)\text{Br}$ gives a tertiary carbocation stabilised by two phenyl rings and a methyl group, the most stable of the four. Benzyl bromide gives only a primary benzylic cation.

38. Answer: (C) $\text{C}_6\text{H}_5\text{OH}$ (phenol)

Phenol is far more acidic ($\text{pK}_a \approx 10$) than any alcohol because the phenoxide ion is resonance-stabilised by the ring. Benzyl alcohol, cyclohexanol and dicyclohexylmethanol give alkoxide ions with no such delocalisation.

39. Answer: (B) III > II > IV > I

Picric acid (2,4,6-trinitrophenol, $\text{pK}_a \approx 0.4$) is the strongest because three $-\text{NO}_2$ groups stabilise the phenoxide; acetic acid ($\text{pK}_a \approx 4.8$) is next, then phenol (≈ 10), then cyclohexanol (≈ 16). Putting phenol above acetic acid is the common trap.

40. Answer: (B) $\text{NaOH}-\text{Br}_2$

Hofmann bromamide degradation: $\text{CH}_3\text{CONH}_2 + \text{Br}_2 + 4\text{NaOH} \rightarrow \text{CH}_3\text{NH}_2$, losing one carbon. PCl_5 or hot conc. H_2SO_4 dehydrate acetamide to acetonitrile, and soda lime does not give methylamine.

41. Answer: (C) Cannizzaro reaction

The Cannizzaro reaction is a disproportionation of an aldehyde into an alcohol and a carboxylate by hydride transfer; no new C-C bond is formed. Friedel-Crafts acylation, Reimer-Tiemann (ring $-\text{CHO}$) and Wurtz coupling all make new C-C bonds.

42. Answer: (A) CH_3COCl

Acyl chlorides are the most reactive acid derivatives: Cl is strongly electron-withdrawing and gives almost no resonance donation to $\text{C}=\text{O}$, and Cl^- is an excellent leaving group. Anhydrides, esters and amides (least) are progressively less reactive.

43. Answer: (B) -0.372°C

Molality = $(68.5/342)/1 \text{ kg} = 0.200 \text{ mol/kg}$. $\Delta T_f = 1.86 \times 0.200 = 0.372 \text{ K}$, so the freezing point is -0.372°C . $+0.372^\circ\text{C}$ has the wrong sign; freezing point is lowered.

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