Chemistry questions for the blitz-tour – answers and brief solutions

1. C_4H_9OH – 4 structural isomers, one of them (2-butanol) has two enantiomers, 5 molecules in total.
$CH_3–O–C_3H_7$ – 2 molecules
$C_2H_5–O–C_2H_5$ – 1 molecule
Total – **8** molecules.

2. $C_2H_5CH(OH)CH_3 + 4I_2 + 6NaOH \rightarrow C_2H_5COONa + 5NaI + CHI_3\downarrow + 5H_2O$
$n(C_2H_5CH(OH)CH_3) = 7.4 / 74 = 0.1$ mol
$n(NaOH) = 0.6$ mol
$m(NaOH) = 0.6 \cdot 40 = 24$ g
$m(solution) = 24 / 0.05 =$ **480** g.

3. $C(Mg^{2+}) = C(CO_3^{2-})$, $C(Na^+) = C(NO_3^-)$, hence, $C(K^+) = C(Cl^-) =$ **22** mM.

4. D-galactose – $C_6H_{12}O_6$, sucrose – $C_{12}H_{22}O_{11}$, they are not isomers of any type.
Correct answer – **5**

5. H_2O – bond angle is 104.5^o, it is less than the tetrahedral angle (109.5^o) because of repulsion of two unshared electron pairs.
NH_3 – angle HNH is closer to the tetrahedral angle than that in H_2O, because in NH_3 molecule there is only one unshared electron pair.
H_2S – the bond angle is close to 90^o due to lack of hybridization.
CH_4 – the tetrahedral bond angle, 109.5^o.
ICl_4^- – the ion has square form, the bond angle is 90^o.
Correct answers – **2, 4**.

6. The initial solution: $C(CH_3COOH) = \dfrac{[H^+]^2}{K} + [H^+] = 1.0$ M.
$C(NaOH) = (2.00/40) / 0.2 = 0.25$ M.
After addition of NaOH we get the buffer solution with $C(CH_3COOH) = 0.75$ M,
$C(CH_3COONa) = 0.25$ M.
$pH = –\lg(1.75 \cdot 10^{-5}) + \lg(0.25/0.75) = 4.28$.
Correct answer – **4**.

7. $XeF_n + (n/2)H_2 = Xe + nHF$
$\Delta P = P(HF) – P(H_2,reacted) = P(H_2,reacted) = 144 – 96 = 48$ Torr
$P(H_2,reacted) / P(Xe) = 2$
$n/2 = 2$
$n =$ **4**.

8. $FeS_2 + 14H^+ + 15NO_3^- = Fe^{3+} + 2SO_4^{2-} + 15NO_2 + 7H_2O$.
The sum of stoichiometric coefficients is **55**.

9. $K = n(IBr)^2 / (n(I_2) \cdot n(Br_2) = 0.6^2 / (0.4–0.2)^2 =$ **9**.

10. For the transition $m \rightarrow n$, $\Delta E \sim \left(\dfrac{1}{m^2} - \dfrac{1}{n^2}\right)$. The largest wavelength corresponds to the smallest ΔE, that is $E_6 – E_3$.
Correct answer – **4**.

11. $Mg(OH)_2 \quad Mg^{2+} + 2OH^-$
$K_{sp} = [Mg^{2+}]\cdot[OH^-]^2 = [OH^-]^3/2$
$[OH^-] = 10^{-3.6}$
$K_{sp} = 10^{-10.8} / 2 = 7.9\cdot10^{-12}$
Correct answer – **7.9** (7.8 is also accepted).

12. We use the Raoult's law.
Let x be the mole fraction of the solute, then
$x = (2.93 - 2.76) / 2.93 = 0.058$.

$$0.058 = \frac{\frac{23}{M}}{\frac{23}{M} + \frac{200}{46}},$$

M = **86** g/mol.

13. The initial solution: $1\ KOH + 8H_2O$
The final solution: $1KOH + 28H_2O$
The mass ratio: $(56+28\cdot18) / (56+8\cdot18) = 2.8$
Correct answer – **4**.

14. $K \sim n(N_2O_4) / (n(NO_2))^2 = 2 / 2^2 = 1/2$.
Fig. 2: $n(N_2O_4) / (n(NO_2))^2 = 1 \neq K$
Fig. 3: $n(N_2O_4) / (n(NO_2))^2 = 1/4 \neq K$
Fig. 4: $n(N_2O_4) / (n(NO_2))^2 = 8 / 4^2 = 1/2 = K$ – the mixture is in equilibrium.
Correct answer – **4**.

15. $Ba(OH)_2 + SO_2 = BaSO_3\downarrow + H_2O$.
Correct answer – **4**.

16. $CH_4 + 2O_2 = CO_2 + 2H_2O(ж)$
CH_4 and O_2 reacted completely, because there are only two gases in the resulting mixture – CO_2 and Ar.
$\Delta V = V(O_2,\text{reacted}) = 20 - 12 =$ **8** mL.

17. $x = 2$.
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^2$ – Ti (8 *s*-electrons, 12 *p*-electrons, 2 *d*-electrons),
the atomic number is **22**.

18. $Se_xS_y + O_2 \rightarrow xSeO_2\downarrow + ySO_2\uparrow$
$x : y = n(SeO_2) : n(SO_2) = (333/111) : (40.3/22.4) = 1.67 = 5 : 3$.
Se_5S_3
Correct answer – **53**.

19. $CH_3CH_2Br \rightarrow CH_3CH_2CN \rightarrow CH_3CH_2COOH \rightarrow (CH_3CH_2COO)_2Ca \rightarrow (C_2H_5)_2CO$
$C_5H_{10}O$
Correct answer – **5101**.

20. Tripeptide is an asymmetric molecule with 6 stereocenters.
The number of stereoisomers = 2^6 = **64**.