2024 ACES State Chemistry Solution Set

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| Answer | Explanation |
| 1. Answer is C. | Precision is shown by closeness of data points to one another. However, the actual (true) value is far from the average value of the collected data.  |
| 2. Answer is D. | The number of electrons outside the nucleus only equals the number of protons in the nucleus, not the combined number of protons and neutrons. |
| 3. Answer is C. | Combustibility represents burning in presence of oxygen, which is a chemical change, not a physical change. |
| 4. Answer is B. | Oxygen and chlorine gases are diatomic species.1. 50 g K x $\frac{1 mol K}{39 g K}$ x $\frac{6.022 x 10^{23} K-atom}{1 mol K}$ = 7.72 x 1023 K-atoms
2. 50 g O2 x $\frac{1 mol O\_{2}}{32 g O\_{2}}$ x $\frac{2 x 6.022 x 10^{23} O-atom}{1 mol O\_{2}}$ = **1.88 x 1024 O-atoms**
3. 50 g Na x $\frac{1 mol Li}{23 g Na}$ x $\frac{6.022 x 10^{23} Na-atom}{1 mol Na} $= 1.31 x 1023 Na-atoms
4. 50 g Mg x $\frac{1 mol Mg}{24.3 g Mg}$ x $\frac{6.022 x 10^{23} Mg-atom}{1 mol Mg} $= 1.23 x 1023 Mg-atoms
5. 50 g Cℓ2 x $\frac{1 mol Cl\_{2}}{70.9 g Cl\_{2}}$ x $\frac{2 x 6.022 x 10^{23} Cl-atom}{1 mol Cl\_{2}}$ = 8.49 x 1023 Cℓ-atoms
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| 5. Answer is B. | The correctly drawn Lewis structure (pictured here) shows a triple bond and only four electron dots.  |  |
| 6. Answer is A. | A ketone consists of two alkyl groups connected to a carbonyl functional group. |
| 7. Answer is B. | The following drawing shows the structures of the reactants and products.  $∆H\_{rxn}^{o}$ = $Σmol bond broken- Σmol bond formed$ = [6 mol (C-H) + 1 mol (C-C)] – [4 mol (C-H) + 1 mol (C=C) + 1 mol (H-H)] = [(6 mol x 410 kJ/mol) + (1 mol x 350 kJ/mol)] – [(4 mol x 410 kJ/mol) +  (1 mol x 617 kJ/mol) + (1 mol x 429 kJ/mol)] = 2810 kJ – 2686 kJ = 124 kJ |
| 8. Answer is C. | Answers A, B, and D increase as intermolecular force of attraction increases.  |
| 9. Answer is A. | With 54 electrons and a charge of 1+, the species must have 55 protons. With 78 neutrons, the mass number is 55 + 78 = 133. |
| 10. Answer is B. | Choice-III describes a neutral solution. The pH of a solution is temperature dependent (pH = 7.00 for a neutral solution only at 25 oC). At the endpoint of a titration of a weak acid with a strong base, for example, the conjugates are in solution, and the conjugate of a weak acid acts as a base; thus, this solution is not neutral. Some salts also exhibit acid or base properties. |
| 11. Answer is D. | Ideal gas law PV = nRT leads to n = $\frac{PV}{RT}$ for constant volume, temperature, and pressure the number of moles, n, remains the same; therefore, the number of molecules will also be the same.  |
| 12. Answer is C. | Use 1 cm = 10 mm leading to 1 cm3 = 1000 mm3. 2.67 × 104 mm3 x $\frac{1 cm^{3}}{1000 mm^{3}}$ = 26.7 cm3 = 2.67 x 101 cm3 in scientific notation |
| 13. Answer is A. | Sulfur produces the sulfide ion, a monoatomic ion S2–, displaying the gain of two electrons to achieve the electron configuration of the nearest noble gas, Ar. |
| 14. Answer is C. | In endothermic processes heat is transferred from the surroundings to the system.  |
| 15. Answer is A. | Use an “ICE” chart: I 2(g) + Br2(g) ⇌ 2 IBr(g) Initial 0.500 0.500 0.000 Change –*x* –*x* 2*x* Equilibrium 0.500–x 0.500–x 0.84Use the IBr column to solve for *x*: 0.00 + 2*x* = 0.84 → *x* = 0.42So, [I2] = [Br2] = 0.500 – 0.42 = 0.080 *M*Calculate *K*eq using the equilibrium data: *K* = ($\frac{[IBr]^{2} }{[I\_{2}] x [Br\_{2}]}$) = ($\frac{0.84^{2} }{0.08 x 0.08}$) = 110 |
| 16. Answer is E. | Plot of ℓn [H2O2] vs time being linear indicates a first order reaction.First find the rate constant, *k*, using the integrated rate law. Then calculate the half-life.ℓn[H2O2]t = –*k*t + ℓn[H2O2]0ℓn 0.075 = –*k*(54 min) + ℓn 0.600 t1/2 = $\frac{0.693 }{k}$ = $\frac{0.693 }{0.0385}$ = 18 min–2.590 = –*k*(54 min) + –0.5108–2.079 = –*k*(54 min) *k =* 0.0385 min–1 |
| 17. Answer is E. | 23.7 g CaCℓ2 x $\frac{1 mol CaCl\_{2}}{110.98 g CaCl\_{2} }$ x $\frac{2 mol Cl^{-}}{1 mol CaCl\_{2} }$ = 0.4272 mole Cℓ–23.7 g CaCℓ2 + 375 g H2O = 398.7 g solution x $\frac{1 mL }{1.05 g}$ = 379.7 mL = 0.3797 LMolarity = $\frac{moles solute }{L of solution}$ = $\frac{0.4272 mole }{0.3797 L}$ = 1.12 *M* |
| 18. Answer is C. | Use the expression for *K*sp to solve for the barium ion molarity. This will be the molar solubility as the ratio of Ba2+ to BaF2 is one-to-one. Consider the F– in the LiF as a common ion.*K*sp = [Ba2+][F–]21.7 x 10–6 = [Ba2+] x [0.0750]23.0 x 10–4 = [Ba2+]Molar solubility is 3.0 x 10–4 *M* |
| 19. Answer is C. | The wavelength is an inconsequential number in this problem. Convert total energy to photons using the given per photon energy. 1.3 x 10–2 J x $\frac{1 photon}{3.10 x 10^{-19} J}$ = 4.2 x 1016 photons |
| 20. Answer is B. | Use the method of initial rates.order with respect to A: order with respect to B: $\frac{rate\_{3}}{rate\_{1}} $= ($\frac{[A]\_{3}}{[A]\_{1}}$)n $\frac{rate\_{2}}{rate\_{1}} $= ($\frac{[B]\_{2}}{[B]\_{1}}$)n $\frac{10.17}{1.13} $= ($\frac{1.35}{0.451}$)n $\frac{1.13}{1.13} $= ($\frac{1.77}{0.885}$)n 9 = $3$n → n = 2 1 = $2$n → n = 0Overall order = 2 + 0 = 2 |
| 21. Answer is B. | Sodium chloride (NaCℓ) is an ionic compound. Benzene (C6H6) is a nonpolar compound. Ion-dipole forces would not be able form between the two; therefore, the solvation of the ions would be very weak in benzene. |
| 22. Answer is D. | A spontaneous redox reaction would have a positive cell potential. The anode is the oxidation half-reaction and the cathode is the reduction half-reaction.for choice A: $E\_{cell}^{o}$ = Ecathode – Eanode = –0.74 –( –0.440) = –0.300 Vfor choice B: $E\_{cell}^{o}$ = Ecathode – Eanode = 0.154 – 0.771 = –0.617 Vfor choice C: $E\_{cell}^{o}$ = Ecathode – Eanode = –0.440 – 0.771 = –1.211 Vfor choice D: $E\_{cell}^{o}$ = Ecathode – Eanode = 0.154 – (–0.74) = **+0.894 V**for choice E: $E\_{cell}^{o}$ = Ecathode – Eanode = –0.440 – 0.154 = –0.594 V |
| 23. Answer is D. | The balanced chemical equation is: 2 S + 3 O2 → 2 SO3Oxygen is the limiting reactant based on the calculations shown:$$1.00 g O\_{2} x \frac{1 mol O\_{2} }{32 g O\_{2} } x \frac{2 mol SO\_{3} }{3 mol O\_{2} } =0.0208 mol SO\_{3} $$$$1.00 g S x \frac{1 mol S }{32.07 g S } x \frac{2 mol SO\_{3} }{2 mol S } =0.0312 mol SO\_{3}$$$$1.0 g O\_{2} x \frac{1 mol O\_{2} }{32 g O\_{2} } x \frac{2 mol S }{3 mol O\_{2} } x \frac{32.07 g S}{1 mol S}=0.668 g S used up$$1.0 g S – 0.668 g S = 0.332 g left over  |
| 24. Answer is E. | Nonmetal oxides are acidic when dissolved in water. Metal oxides are basic when dissolved in water. The only nonmetal oxide, based on the choices given, would be carbon dioxide. |
| 25. Answer is B. | First calculate the energy of the emitted light:ΔE = –2.18 x 10–18 J x ($\frac{1}{n\_{f}^{2}}-\frac{1}{n\_{i}^{2}})$ = –2.18 x 10–18 J x ($\frac{1}{2^{2}}-\frac{1}{5^{2}})$ ΔE = –2.18 x 10–18 J x (0.210) = –4.578 x 10–19 JCalculate the wavelength using the energy.E = $\frac{hc}{λ}$ → 4.578 x 10–19 J = $\frac{(6.626 x 10^{-34} J▪s)(3.00 x 10^{8} \frac{m}{s})}{λ}$ $λ$ = 4.34 x 10–7 m = 434 nm |
| 26. Answer is E. | Use the boiling point data to find the Van’t Hoff factor (i).ΔTb = *m* x *kb* (102.1 – 100) = 2.05 *m* x 0.51 ⁰C/*m* x ii = 1.91 ≈ 2 → NaCℓ is the only choice with an i value of 2. |
| 27. Answer is B. | The photoelectric effect is observed in experiments where electromagnetic radiation is used to eject electrons from a metal. |
| 28. Answer is C. | 2 NO(g) ⇌ N2(g) + O2(g)  Initial 36.1 0 0 Change –2*x* *x* *x* Equilibrium 36.1–2x x x*K*p = ($\frac{[N\_{2}] x [O\_{2}] }{[NO]^{2} }$) 2.40 x 103 = ($\frac{[x] x [x] }{[36.1-2x]^{2}}$) = ($\frac{x^{2} }{[36.1-2x]^{2}}$) this is a perfect square, so square root48.99 = $\frac{x }{36.1-2x }$48.99 x (36.1 – 2x) = x 1768.54 – 97.98x = x1768.54 = 98.98 x Poxygen = x = 17.9 atm  |
| 29. Answer is A. | When wavelength increases, frequency and energy will decrease, the amplitude will not be affected. Visible light will become more red, not more violet. |
| 30. Answer is E. | Electron affinity generally becomes more negative going left to right on the periodic table. The element with the most negative electron affinity in any row on the periodic table would be in group 7 (the halogens). Choice E is the halogen electron configuration as it has 7 valence electrons. |
| 31. Answer is D. | Degenerate means equal energy. The only choice would be a 3d orbital. The only legitimate 3d orbital among the choices is the 3dyz. The 3dzz is not a correct 3d orbital.  |
| 32. Answer is D. | A buffer is a mixture of a weak acid and its conjugate base. Buffers can also be generated by mixing a strong base with a weak acid. HCℓ and NaCℓ would be a mixture of a strong acid and its conjugate base. This would not be a buffer. |
| 33. Answer is A. | Colligative properties are vapor pressure lowering, boiling point elevation, freezing point depression and osmotic pressure. |
| 34. Answer is E. | Chromium (III) would lose its one 4s electron and two 3d electrons giving [Ar]3d3. |
| 35. Answer is E. | Atom mass, g mol ratio to smallest mol multiply to make wholeC 68.84 5.74 3.5 7H 4.95 4.95 3.0 6O 26.21 1.64 1.0 2 |
| 36. Answer is D. | Out of the two possible charges gallium assumes a 3+ charge in this formula, and perbromate is BrO4–. The combination produces Ga(BrO4)3. |
| 37. Answer is A. | Being an ionic compound with metal ion for a cation, Na2S, is solid at room temperature. The other choices are covalent compounds.  |
| 38. Answer is A. | Utilization of n = $\frac{m}{M}$ in PV = nRT generates, $M$ = $\frac{mRT}{PV}$. T in K = 45 + 273 = 318 K. $M$ = $\frac{4.37 g x 318 K x 0.0821 \frac{L . atm}{mol . K}}{1 atm x 3.00 L}$ = 38 g/mol. Only F2 fits in this molar mass. |
| 39. Answer is D. | pH = –log [H+] leads to [H+] = 10–pH *M*. pH of 5 gives 10–5 *M* and pH of 4 gives 10–4 *M*, the latter being 10 higher in H+ concentration. |
| 40. Answer is E. | A conjugate base is the species that is has one proton less than the acid. Sulfuric acid’s (H2SO4) conjugate base, therefore, is HSO4–. |