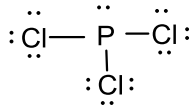
2022 ACES Regional Chemistry Solution Set

Answer	Explanation
1. Answer is B.	All but mass change as a consequence of this phase change. Volume increases dramatically and density decreases. A significant amount of heat must be absorbed to transform ice to a gas.
2. Answer is E.	Sodium ion is Na^+ and chlorate ion is $C\ell O_3^-$.
3. Answer is C.	Combustibility is associated with chemical change.
4. Answer is A.	 The complete Lewis structure is:
5. Answer is A.	The count of three oxygen atoms are represented by subscript 3 after oxygen atom.
6. Answer is C.	q = m c ΔT; = 6.30 g x 0.129 $\frac{J}{g\,.^{\circ}C}$ x (29.7 – 25.0) °C = 3.82 J.
7. Answer is B.	The molecule NO contains an odd number of valence electrons while octet represents an even number of valence electrons.
8. Answer is C.	The decreasing order of intermolecular force is hydrogen bonding, then dipole forces and dispersion force. HF has all three. While both CO_2 and H_2 have only dispersion force, the former one has at higher amount.
9. Answer is D.	Melting, boiling, sublimation, and evaporation require absorption of external energy.
10. Answer is D.	At neutral pH, a value of 7, at 25 °C, the hydronium and hydroxide ion concentrations are equal and 1 x 10^{-7} M.
11. Answer is A.	pH = –log $[H^+]$ = –log(6.45 x 10^{-5} M) = 4.19
12. Answer is B.	It follows the mathematical rule.
13. Answer is E.	PV = nRT; V = $\frac{nRT}{P}$ = $\frac{\frac{12.0\ g}{44\ g/mol} \times 0.0821 \frac{L\,.atm}{mol\,.K} \times (65.0+273.15)K}{2.00\ atm}$ = 3.79 L
14. Answer is E.	Alpha particles are heavy and less penetrating, thus can be stopped by dense paper.
15. Answer is A.	185.0 g $FeC\ell_3$ x $\frac{1\ mol\ FeC\ell_3}{162.2\ g\ FeC\ell l_3}$ x $\frac{3\ moles\ C\ell_2}{2\ moles\ FeC\ell_3}$ = 1.711 moles $C\ell_2$
16. Answer is B.	Vapor pressure is lowered based on the number of dissolved particles in solution. $NaC\ell$, $CaBr_2$ and $A\ell(NO_3)_3$ are all ionic; therefore, they have 2 or more dissolved particles in solution. $C_6H_{12}O_6$ is molecular (1 dissolved particle). $C_6H_{12}O_6$ will have the highest vapor pressure.
17. Answer is C.	K equals the concentration of the products over the concentration of the reactants, with each concentration raised to a power that is equal to the stoichiometric coefficient. $\frac{[SO_3]^2}{[SO_2]^2[O_2]}$

18. Answer is E.	E = hv with frequency being in Hz. 89.9 MHz x $\frac{10^6\ \text{Hz}}{1\ \text{MHz}}$ = 8.99 x 10^7 Hz E = (6.626 x 10^{-34} J·s^{-1}) x (8.99 x 10^7 s^{-1}) = 5.96 x 10^{-26} s^{-1}.
19. Answer is D.	Ionization energy increases left to right and decreases going down the periodic table. Radius decreases left to right and increases going down the periodic table. Aℓ having a lower ionization energy than Si is the only option that follows these trends.
20. Answer is E	250 g HBr x $\frac{1\ \text{mol HBr}}{80.91\ \text{g HBr}}$ = 3.09 moles; 100 g H_2O x $\frac{1\ \text{mole}\ H_2O}{18.02\ \text{mol}\ H_2O}$= 5.55 moles mole fraction = $\frac{\text{moles solute}}{\text{moles solute+moles solvent}}$ = $\frac{3.09}{(3.09+5.55)}$ = 0.358
21. Answer is A.	It is the minimum whole number coefficient for oxygen.
22. Answer is E.	Diamagnetic indicates that the element would have all of its electrons paired. This is only possible if all sublevels are full. [Ar]$4s^2 3d^{10}$ is only option with all sublevels full.
23. Answer is C.	Electron affinity increases left to right on the periodic table. However, noble gases do not have electron affinities; therefore, the halogens would have the highest values.
24. Answer is D.	Longest wavelength would result in the lowest energy transition. Due to quantized energy levels, the 4→3 transition results in the lowest energy.
25. Answer is B.	Solid solubility with temperature depends on the ΔH of dissolution. Endothermic dissolution of a solid is enhanced with increasing temperature.
26. Answer is A.	$HC_2H_3O_2$ has a total of 4 hydrogens. So, 15.50 g $HC_2H_3O_2$ x $\frac{1\ \text{mol}\ HC_2H_3O_2}{60.06\ \text{g}\ HC_2H_3O_2}$ x $\frac{4\ \text{mol H}}{1\ \text{mol}\ HC_2H_3O_2}$ x $\frac{1.01\ \text{g H}}{1\ \text{mol H}}$ = 1.043 g H
27. Answer is D.	The last electron in a scandium atom would be the 3*d* electron. Therefore, n = 3 and ℓ = 2.
28. Answer is D.	^{0} C = K -273; therefore, ^{0} C = 412-273 = 139 ^{0} C
29. Answer is E.	The process of using density and mass to get a volume tells us what that 5.00 mL should weigh (its true value). Therefore, comparison with the measured mass tells us how close the pipette is to the true value.
30. Answer is D.	The graduation marks allow you to measure certainty to 10.0, while the last digit is uncertain and represents an estimate based on how far the meniscus is between graduation marks.
31. Answer is C.	"Iso" means equal and "electronic" refers to the electrons within an atom. Thus, a series of atoms with equal numbers of electrons is isoelectronic.
32. Answer is B.	Hydrogen is defined as an element with 1 proton. So to be neutral it would always have 1 electron.
33. Answer is D.	The chemical formula for this compound is P_2O_5.
34. Answer is B.	8.0 % of the mass must be hydrogen. Eight percent of 25.0 is 2.00.

35. Answer is E.	Assuming 100 grams of the compound, there would be 1.25 moles of iron $(69.9\ \text{g Fe} \times \frac{1\ \text{mol Fe}}{55.8\ \text{g Fe}})$ and 1.88 moles of oxygen $(30.1\ \text{g O} \times \frac{1\ \text{mol O}}{16.0\ \text{g O}})$. Dividing both moles by 1.25 gives a mole ratio of 1 iron to 1.5 oxygen. Changing these to whole number ratios yields a formula of Fe_2O_3.
36. Answer is B.	The equation for the dissociation of this compound is $\text{Ag}_2\text{CrO}_4(\text{s}) \rightarrow 2\text{Ag}^+(\text{aq}) + \text{CrO}_4{}^{2-}(\text{aq})$. In equilibrium expressions, coefficients in the balanced equation become exponents.
37. Answer is A.	In first order radioactive decay kinetics, the rate law is $\text{rate} = \text{k}[\text{A}]$ where [A] is the concentration of radioactive isotope. Integration of this rate law and solving for a half-life yields $\text{t}_{1/2} = \frac{\ln 2}{\text{k}}$, which can be solved as $\text{k} = 0.693/22.3\text{yrs}$ = 0.0311 yr^{-1}
38. Answer is C.	"d" orbitals occur in the $l = 2$ angular momentum quantum number. While s orbitals ($l = 0$) are spherical and p orbitals ($l = 1$) are figure 8 shapes, four of the d orbitals are 4-leaf clover shaped (with d_{z^2} being a single figure 8 shape with a torus around it).
39. Answer is C.	Reduction potentials reflect the likelihood of a species attracting electrons in a chemical reaction as in $\text{X} + \text{e}^- \rightarrow \text{X}^-$. Metals like to lose electrons and thus form stable cations that are not easily reduced. Iodine has a lower electronegativity than fluorine and thus has a weaker affinity for electrons.
40. Answer is A.	The salt bridge is there to balance the charge differential created as electrons move from one half-reaction to the other. It does this by providing a pathway for ions to move as charged differentials build up. Without a salt bridge, the electron movement would quickly cause an electrical charge differential that would impede the further movement of any electrons.