2013 Academic Challenge Regional Chemistry Exam Solution Set

1. E. N^{3-} and P^{3-} contain different numbers of protons AND different numbers of electrons.

2. B. X and Z have the same number of protons, but different mass numbers, indicating a different number of neutrons.

3. E. $P_1V_1 / T_1 = P_2V_2 / T_2$

$(0.105 \text{ atm})(2.00 \text{ L}) / 253 \text{ K} = P_2 (4.50 \text{ L}) / 330 \text{ K}$

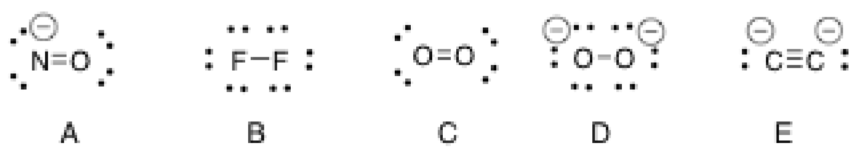
$P_2 = 0.0609 \text{ atm}$

4. C. The answer is C.

5. C. $(13.6\text{g/cm}^3)(1\text{kg}/1000\text{g})(2.2\text{lb}/1 \text{ kg})(2.54\text{cm}/1.0 \text{ in})^3 = 0.4903 \text{ lb/in}^3$

6. D. The process is condensation – exothermic.

7. E. C_2^{2-} is the only one with a triple bond in its Lewis structure.



8. B. This option yields the correct balance of protons and mass number.

9. D. Only options I. and III. are physical changes.

10. B. The answer is B.

11. B. The answer is B.

12. E. Atomic masses are smallest at the top, right hand corner of the periodic table.

13. B. The least precise instrument limits the precision of the overall measurement, but then you are able to report an additional decimal place.

14. D. The answer is D.

15. A. Only option III is true.

16. E. $107.1 \text{ MHz } [1\text{x}10^6 \text{ Hz} / 1 \text{ MHz}] = 1.071\text{x}10^8 \text{ Hz (or s}^{-1})$

$c = \lambda \bullet \nu$

$2.998\text{x}10^8 \text{ m/s} = \lambda \bullet 1.071\text{x}10^8 \text{ Hz}$

$\lambda = 2.799 \text{ m}$

17. D. Assume you have 1.00 mol of D to start. This yields 0.48 mol of E.

% yield overall = (0.48 mol)(0.73) = 0.35 mol F

2013 Academic Challenge Regional Chemistry Exam Solution Set

18. C. The answer is C.

19. D. mol O_2 = 7.05 g $KClO_3$ [1 mol $KClO_3$/122.5 g $KClO_3$][3 mol O_2/2 mol $KClO_3$] =0.0863 mol

20. B. mol of Li = 1.62 g Li [1 mol Li / 6.941 g Li] = 0.233 mol Li
mol of O_2 = 6.00 g O_2 [1 mol O_2 / 32.0 g O_2] = 0.1875 mol O_2
0.233 mol Li (1 mol O_2/4 mol Li) = 0.0585 mol O_2 needed. 0.01875 is present therefore Li is the limiting reagent.

Mass Li_2O = 0.233 mol Li [2 mol Li_2O /4 mol Li][29.88 g Li_2O /1 mol Li_2O]
= 3.5 g

21. C. The answer is C, according the Le Chatelier principle. A higher temperature will shift the equilibrium in the direction of the endothermic reaction. A low pressure will favor the side of the equilibrium with more particles in the gas phase.

22. D. 1000. mL (1.0 quart/0.95 L) = 1052 mL so a small amount (5.2%) of the tea spills

23. A. The answer is A.

24. E. All the other options are true statements, but they describe other gas laws.

25. D. (453.25 g Al)(1 mol Al/26.9815 g)(5 mole products/2mol Al) = 41.996 mol

26. A. All acids listed have the same molarities, so the one with the lowest pK_a value will have the highest concentration of H^+ in solution at equilibrium and therefore the lowest pH.

27. B. (0.300 L NaOH)(0.10 mol NaOH/L) = 0.03 mol NaOH
(0.300 L HCl)(0.15 mol HCl/L) = 0.045 mol HCl
[H_3O^+] leftover = (0.045-0.03)/ 0.600 L = 0.025 M

28. E. M NaOH = [50.0 g / 40.997 g/mol] / 0.750 L = 1.67 M

29. A. $Pb(NO_3)_2$ (aq) + 2KBr (aq) $\rightarrow$ $PbBr_2$ (s) + 2KNO_3 (aq)

30. B. The answer is B.

31. A. H_2 has the lowest molecular weight and therefore will contain the most particles in 10.0 g. According to Avogadro's Law, the volume is proportional to the number of particles at constant pressure and temperature.

32. C. Volume and moles are constant.
$P_1 / T_1 = P_2 / T_2$
1.5 atm / 298 K = P_2 / 373 K
P_2 = 1.88 atm

2013 Academic Challenge Regional Chemistry Exam Solution Set

33. D. Atoms with the largest, most negative electron affinities are at the top right corner of the periodic table.

34. B. The answer is B.

35. D. $2H_2O + U^{3+} \rightarrow UO_2^{2+} + 4H^+ + 3e^-$

36. D. $^{1}H^{35}Cl$, $^{1}H^{37}Cl$, $^{2}H^{35}Cl$, $^{2}H^{37}Cl$, $^{3}H^{35}Cl$, $^{3}H^{37}Cl$ for 6 possible isotopes

37. C. A. 40.0% B. 52.1% C. 79.9% D. 37.4% E. 26.0%

38. B. Use the integrated first-order rate law.

$\ln A = \ln A_0 - kt$

$\ln 55 = \ln 100 - k\,(33\text{ min.})$

$k = 0.0181\text{ min}^{-1}$

$t_{1/2} = \ln 2 / k$

$t_{1/2} = 38\text{ min.}$

39. A.

40. D. The answer is D.