<u>2012 Academic Challenge Chemistry Regional Test – Solution Set</u>

1. A. Use $M_1V_1=M_2V_2$ and solve for V_2: such that (0.100 L)(6.0 M) = (0.54 M) V_2.

2. C. The carbonate ion does not break down so the correct answer is C.

3. C. In C, the possible ionic compound precipitates could be KNO_3 and $BaCl_2$. Both of these salts are relatively soluble, so they are able to exist in a moderate concentration. All other options have combinations of ions where there would be at least one precipitate.

4. B. First solve for the pOH = 14.00 – 4.48 = 9.52. Then [OH-] = $10^{-9.52}$.

5. B. Isotopes have the same number of protons but differing numbers of neutrons.

6. B. B is the only option in which the oxidation numbers do not change.

7. D. q = (7.50×10^4 g) (0.710 J/°C•g)(54 K) = 2.87×10^6 J. The final answer is equal to D when converted to kJ.

8. C. At point C, there is no further change in concentration.

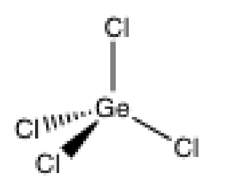
9. D. 328g Cr_2O_3 (1 mol Cr_2O_3/152g)(3 mol SiO_2/2 mol Cr_2O_3)(60.05 g/1mol SiO_2) = 194g

10. A. Assume a 100 g sample of the unknown so the percentages can be used as masses. Then solve for moles of Cl, C, and H.

    Mol Cl = 71.65 g [1 mol/35.45 g] = 2.02 mol
    Mol C = 24.27 g [1 mol/12.011 g] = 2.02 mol
    Mol H = 4.07 g [1 mol/1.008 g] = 4.07 mol
    Emp. Formula: $C_{2.02}H_{4.07}Cl_{2.02}$ = divide each by 2.02 = CH_2Cl

11. B. The picture is of the dz^2 orbital.

12. D. The VSEPR shape at Ge is tetrahedral.



13. B. The Lewis structure is on the right.

14. A. If you cut [A] in half, the rate decreases by a factor of 4. If [B] is doubled the rate is doubled. The net change is to decrease the overall rate by a factor of 2.

15. C. The sum of the oxidation numbers must equal -2. O is -2, so Cr should be +6.
    -2 = 2 (ox. Cr) + 7(-2)

16. C. 3.227×10^{23} atoms

    78.82 g $K_2Cr_2O_7$[1 mol/294.2 g $K_2Cr_2O_7$][2 mol Cr/1 mol $K_2Cr_2O_7$][6.022×10^{23}/1 mol Cr]

17. E. ^{14}C has 6 protons and 8 neutrons. ^{14}N has 7 protons and 7 neutrons.

18. D. Multiply the percent abundance by the atomic mass and then sum to get the weighted average. The weighted average is 91.224 amu, which corresponds to Zr on the periodic table.

19. B. Assume that Li is the limiting reagent by calculating the maximum amount of Li_2O that could be formed and then do the same calculation assuming O_2 is the limiting reagent. Li produces the least amount of lithium oxide.

    Mass Li_2O if Li is LR
    = 1.62 g[1 mol Li/6.941g Li][2 mol Li_2O/4mol Li][29.9 g Li_2O/1 mol Li_2O]
    = 3.50 g

    Mass Li_2O if O_2 is LR
    = 6.00 g[1 mol O_2/32.00 O_2][2 mol Li_2O/1mol O_2][29.9 g Li_2O/1 mol Li_2O]
    = 11.2 g

20. B. H_2 has the smallest molecular weight, so it will require the largest number of moles to match the mass of the others. The largest number of moles will result in the largest volume according to Avogadro's Law.

21. B. Use the general gas law of $P_1V_1/n_1T_1 = P_2V_2/n_2T_2$. V1=V2. Note that n_2 will be 1.15-0.48 moles = 0.67 moles and the temperatures should be converted to K.

22. B. The answer is B.

23. D. The answer is D. Simplest solution is to convert all volumes to liters.

24. D. First ionization energy represents the loss of an electron from the gaseous neutral atom. All first ionization energies are endothermic.

25. B. The answer is B as radius increases down and to the left on the periodic table.

26. C. 13.6 g/cm^3 (1kg/1000g)(2.2lb/1.0 kg)(2.54 cm/1.0 in)^3 = 0.491 lb/cm^3.

27. D. Granite has the highest heat capacity and therefore requires the most thermal energy to increase the temperature to 100 ºC. Granite therefore has the most energy that it can give to the cold room.

28. E. positron decay represent the loss of a positron (positively charged electron) and the position is symbolized as a ${}^{0}{}_{1}e$ or ${}^{0}{}_{1}\beta$.

29. A. The electron configuration for each of the answers is below. Only V^{3+} has its 3 d electrons with parallel spins in degenerate orbitals.

    a) [Ar]$3d^2$
    b) [Kr]$4d^{10}$
    c) [Ar]$3d^2$
    d) isoelectronic with Ar
    e) [Ar]$3d^{10}$

30. D. CaI_2 is ionic.

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31. D. Equilibrium constant expressions are products over reactants each raised to their stoichiometric coefficients.

32. A. The answer is A—salt bridges allow for the movement of ions, not free electrons.

33. E. E is the only correct statement. For A, the solid has a higher density than the liquid, according to the positive fusion curve. For B, the triple point is A, which is lower than its normal melting point (ie. the melting temperature at 760 mmHg). For answers C and D, the line between points C and D represents the phase change from a solid to a gas.

34. C. (0.48)(0.73) = .3504 *100 = 35%

35. C. Only the mixture and subsequent reaction of the reagents in C lead to a mixture of a weak base (NH_3) and its weak conjugate acid (NH_4^+). Note that the conjugate acid is produced by the reaction of the NH_3 with the HCl. Give then amounts of both starting materials a buffer will result.

36. A. All acids listed are the same molarity, so the one with the highest K_a will be the strongest acid and therefore the lowest pH.

37. E. Use the graph to approximate what the temperature will be at the intersection of the vapor pressure curve at 1.32 atm (which is 1003 torr-approximately the top of the graph).

38. B. The lead has a positive 4 oxidation state and therefore there must be 2 oxygen atoms per molecule to allow for a neutral compound.

39. C. mass P_4:

    = 125 g H_3PO_4[1mol/97.994 g][1 mol P_4/4mol H_3PO_4][123.88 g/ 1 mol P_4]

40. B. The answer is B, since the molecules of a gas do not all move at the same speed at a constant temperature. They have an average kinetic energy.