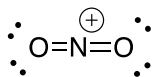


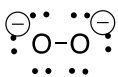
# Academic Challenge Chemistry 2013 State Exam Solution Set

1. E.  $l=2$  is not possible for As. There are no 4d electrons.

2. C.



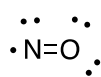
A



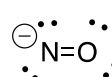
B



C



D



E

3. D.  $\text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{CO}_2 + \text{H}_2\text{O}$

4. C.

$$\begin{aligned} \text{S atoms} &= 2.97\text{g S}_8 [1\text{mol S}_8 / 256.52\text{g S}_8] [8\text{mol S atoms} / 1\text{mol S}_8] [6.022 \times 10^{23} \\ \text{S atoms} / 1\text{mol S atoms}] &= 5.58 \times 10^{22} \text{ S atoms} \end{aligned}$$

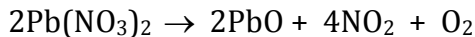
$$\begin{aligned} \text{g P}_4 &= 5.58 \times 10^{22} \text{ P atoms} [1\text{mol P atoms} / 6.022 \times 10^{23} \text{ P atoms}] [1\text{mol P}_4 / 4\text{mol P} \\ \text{atoms}] [123.88 \text{ g P}_4 / 1\text{mol P}_4] &= 2.87 \text{ g} \end{aligned}$$

5. C. A buffer needs a weak acid/base and its conjugate. The HCl will convert half of the  $\text{NH}_3$  into  $\text{NH}_4^+$  resulting in a buffer.

6. D. Let x be the percent abundance of  $^{121}\text{Sb}$ .

$$\begin{aligned} 120.904x + 122.904(1-x) &= 121.76 \\ x &= 0.572 \end{aligned}$$

7. E. First the equation must be written and balanced.



$$\begin{aligned} \text{g Pb}(\text{NO}_3)_2 &= 12.45\text{g NO}_2 [1\text{mol NO}_2 / 46\text{g NO}_2] [2\text{mol Pb}(\text{NO}_3)_2 / 2\text{mol NO}_2] \\ [331.2 \text{ g} / 1\text{mol}] &= 44.82 \text{ g (if 100\% yield)} \\ \text{initial amount of Pb}(\text{NO}_3)_2 &= 44.82 / 0.715 = 62.68 \text{ g} \end{aligned}$$

8. D. Ionization of  $\text{Mg}^+$  is shown as  $\text{Mg}^+ \rightarrow \text{Mg}^{2+} + 2e^-$ . This is the reverse of the electron affinity equation for  $\text{Mg}^{2+}$ .

$$\begin{aligned} 9. \text{ D. } K_{sp} &= [\text{Mg}^{2+}][\text{OH}^-]^2 \\ 1.2 \times 10^{-11} &= (0.010 \text{ M})(x)^2 \\ x &= 3.5 \times 10^{-5} \text{ M} \end{aligned}$$

10. B. One electron is ejected for every one photon.

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11. C.  $\text{mol O}_2 = 30.8 \text{ g} [1 \text{ mol} / 32.0 \text{ g}] = 0.9625 \text{ mol O}_2$   
 $\text{Mass CO}_2 = [0.5] [0.9625 \text{ mol}] [44.0 \text{ g} / 1 \text{ mol}] = 21.2 \text{ g}$
12. B.  $\text{Rate} = k [\text{BrO}_3^-]^x [\text{Br}^-]^y [\text{H}^+]^z$  Units on rate are  $\text{M/s}$  and for  $k$  the units are  $\text{M}^{-3} \text{s}^{-1}$  therefore if  $x=1$  and  $y=1$  then  $z=2$
13. A. This is the only compound which is only an H-bond acceptor. All the others are both donors and acceptors.
14. C. The answer is C.
15. C.  $\text{mol A} = (0.0437 \text{ L})(0.731 \text{ M}) = 0.0319 \text{ mol A}$   
 $\text{Mol B} = (0.02326 \text{ L})(0.412 \text{ M}) = 0.00958 \text{ mol B}$   
 Ratio of A:B = 3:1. It takes three times as many moles of A to reach the stoichiometric equivalence point.
16. A.
- |   |                           |                      |                             |     |                           |
|---|---------------------------|----------------------|-----------------------------|-----|---------------------------|
|   | $\text{PbBr}_2(\text{s})$ | $\rightleftharpoons$ | $\text{Pb}^{2+}(\text{aq})$ | $+$ | $2\text{Br}^-(\text{aq})$ |
| I |                           |                      | 0                           |     | 0                         |
| C | -x                        |                      | +x                          |     | +2x                       |
| E |                           |                      | x                           |     | 2x                        |
- $2x = 0.023 \text{ M} \quad x = 0.0115 \text{ M}$
- $K_{\text{sp}} = [\text{Pb}^{2+}][\text{Br}^-]^2 = (0.0115)(0.023)^2 = 6.1 \times 10^{-6}$
17. D. Multiply first equation by 2. Reverse third equation. Keep second equation as it is.  
 $2(131.3) + (-206.1) + (-41.2) = 15.3 \text{ kJ}$
18. C. Reaction is endothermic so high temperature will favor products.  
 Products have a greater number of moles so low pressure will favor products (greater entropy)
19. D.  
 $\Delta T_b = iK_b m \quad 1.4 = (i)(0.52)(1.35 \text{ m}) \quad i=2$ . KCl ionizes into two ions when dissolved.
20. B.  $\text{mol} = 2.98 \times 10^{22} / 6.022 \times 10^{23} = 0.04949 \text{ mol}$   
 $\text{g/mol} = 4.00 \text{ g} / 0.04949 \text{ mol} = 80.8 \text{ g/mol or amu}$
21. D.  $\text{mol glucose} = 109 \text{ g} / 180.2 \text{ g mol}^{-1} = 0.605 \text{ mol}$   
 $\text{mol water} = 920.0 \text{ mL} [1 \text{ g} / 1 \text{ mL}] [1 \text{ mol} / 18.015 \text{ g}] = 51.07 \text{ mol}$   
 $P_{\text{soln}} = (51.07 / (51.07 + 0.605))(23.76 \text{ mmHg}) = 23.48 \text{ mmHg}$
22. D. The one with the smallest molecular weight.
23. A.

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$$\begin{aligned}\text{mol Ba(OH)}_2 &= 70.28 \text{ g} [1\text{mol}/171.343\text{g}] = 0.410 \text{ mol} \\ \text{M Ba(OH)}_2 &= 0.410 \text{ mol}/2.300\text{L} = 0.178 \text{ M} \\ (0.178 \text{ M}) V_1 &= (0.100 \text{ M})(1.00\text{L}) \quad V_1 = 0.562 \text{ L}\end{aligned}$$

24. C. Use the Arrhenius equation.

$$\begin{aligned}\ln(k_2/k_1) &= -(E_a/R)(1/T_2 - 1/T_1) \\ \ln(3/1) &= -(E_a/8.314)(1/313 - 1/293) \\ E_a &= 4.19 \times 10^4 \text{ J/mol}\end{aligned}$$

25. C. AgCl is insoluble so will not contribute to the concentration. Therefore:  
 $0.100\text{M CaCl}_2 \cdot (2\text{mol Cl}^-/1 \text{ mol CaCl}_2) = 0.200 \text{ M}$

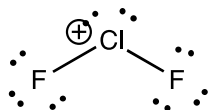
26. D. Same T, P, and V therefore the same number of moles of gas present for each. As they are at the same temperature they have the same average kinetic energy and the heavier CO<sub>2</sub> molecules must be moving slower.

27. B. Mn<sup>2+</sup>: [Ar]3d<sup>5</sup> therefore 5 unpaired electrons

28. A. The answer is A.

29. B. The answer is B, according to the Gibbs Free Energy equation.

30. D.



31. C. The answer is C. Evaporation and melting are examples of physical changes.

32. E.

$$\begin{aligned}\text{Mol C} &= 76.34 \text{ g} [1\text{mol}/12.011\text{g}] = 6.36 \text{ mol} \\ \text{Mol H} &= 6.41 \text{ g} [1\text{mol}/1.008 \text{ g}] = 6.36 \text{ mol} \\ \text{Mol F} &= 17.25 \text{ g} [1\text{mol}/19.00\text{g}] = 0.908 \text{ mol} \\ \text{Emp. Formula: } &\text{C}_7\text{H}_7\text{F}_1 - \text{total of 15 atoms}\end{aligned}$$

$$\begin{aligned}33. \text{ C. } \quad &\text{Cu}^{2+} + \text{Pb} \rightarrow \text{Cu} + \text{Pb}^{2+} \\ &E_{\text{cell}}^\circ = 0.339 \text{ V} + 0.130 \text{ V} = 0.469 \text{ V} \\ &\Delta G^\circ = -(2 \text{ mol e}^-)(96485)(0.469 \text{ V}) = -9.05 \times 10^4 \text{ J}\end{aligned}$$

34. B. Reduction potentials are measured relative to the Standard Hydrogen Electrode (SHE) which is  $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$  and defined as 0 so any listed half reactions that are negative would react spontaneously

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35. D.

$$\text{Mol H}_2\text{SO}_4 = 5.62 \text{ mol FeS}_2 [8 \text{ SO}_2 / 4 \text{ FeS}_2] [2 \text{ SO}_2 / \text{SO}_2] [2 \text{ SO}_3 / 2 \text{ SO}_2] [1 \text{ H}_2\text{SO}_4 / 1 \text{ SO}_3] \\ = 11.2 \text{ mol}$$

36. D. The answer is D.

37. A. edge length =  $\sqrt{8}r$

$$407 \text{ pm} = \sqrt{8} r$$

$$r = 144 \text{ pm}$$

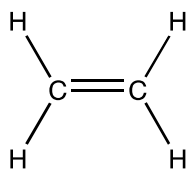
38. E.

$$t_{1/2} = 0.693/k = 7.8 \quad k = 0.088 \text{ min}^{-1}$$

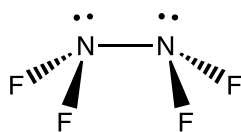
$$\ln(1/32) = \ln 1 - 0.088 t$$

$$t = 39 \text{ min.}$$

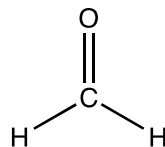
39. E. Both B and D have atoms that do not lie all in the same plane.



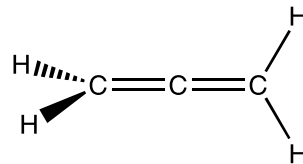
A



B



C



D

40. D. The N is  $sp^2$  hybridized. The p orbital is being used to make the pi bond with C. There is a remaining  $sp^2$  orbital to hold the lone pair.

