

(30 points, 3 each) Circle the one best answer.

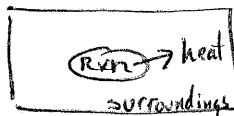
(a) Which statement is true?

- a) A 70.0 g sample of  $\text{Cl}_2$  has more particles than a 20.2 g sample of Ne.
- b) A mole of  $^{35}\text{Cl}$  atoms has a mass of 35 g.
- c) A mole of  $\text{N}_2$  contains  $1.204 \times 10^{23}$  atoms.
- d) A mole of gaseous  $\text{Cl}_2$  has more mass than a mole of solid  $\text{N}_2$ .
- e) I don't know. Please give me a half point.

$$70.91 \frac{\text{g}}{\text{mol}} > 28.01 \frac{\text{g}}{\text{mol}} \\ \text{Cl}_2 \quad \text{N}_2$$

(b) A chemical reaction <sup>spontaneously</sup> releases 250 J of heat.  ~~$\Delta H_{\text{surroundings}} =$~~  The reaction is  $\text{Cl}_2$

- a) +250 J, because energy is conserved. **endergonic**
- ~~b) 0 J, because the energy is conserved. **neutral**~~
- ~~c) -250 J, because the reaction is exothermic.~~
- ~~d) +250 J because the reaction is endothermic.~~
- e) I don't know. Please give me a half point.



(c) The nucleus of an atom

- a) is a 1s orbital.
- b) is negatively charged.
- c) occupies most of the volume of the atom.
- d) contains most of the mass of an atom.
- e) I don't know. Please give me a half point.

(d) Which of the following does not have 18 electrons?

- a) a gaseous hydrogen chloride molecule
- b) a potassium nucleus
- c) an argon atom
- d) a  $3^-$  anion of phosphorus
- e) I don't know. Please give me a half point.

(e) Sr and Br combine to form an ionic compound. The formula of this compound is

- a)  $\text{SrBr}_2$ .
- b)  $\text{SrBr}$ .
- c)  $\text{Sr}_2\text{Br}$ .
- d)  $\text{Sr}_2\text{Br}_2$ .
- e) I don't know. Please give me a half point.

(f) Identify the spectator ions (the soluble cation and anion) in this reaction:



- a)  $\text{Fe}^{2+}$  and  $\text{SO}_4^{2-}$
- b)  $\text{Fe}^{2+}$  and  $\text{OH}^-$
- c)  $\text{Na}^+$  and  $\text{SO}_4^{2-}$
- d)  $\text{Na}^+$  and  $\text{OH}^-$
- e) I don't know. Please give me a half point.

(g) A pure substance made up of more than one type of atom is a

- a) mixture.
- b) compound.
- c) isotope.
- d) solution.
- e) I don't know. Please give me a half point.

(h) Rank the following bonds by increasing polarity

- a) Li-Cl < K-Cl < S-Cl < P-Cl < Si-Cl
- b) S-Cl < P-Cl < Si-Cl < K-Cl < Li-Cl
- c) K-Cl < Li-Cl < Si-Cl < P-Cl < S-Cl
- d) S-Cl < P-Cl < Si-Cl < Li-Cl < K-Cl
- e) I don't know. Please give me a half point.

using only the periodic table

(i) A covalent bond forms between two atoms when

- a) the energy of the bonded atoms is higher than the energy of the un-bonded atoms.
- b) one atom completely transfers an electron to the other atom.
- c) the two nuclei fuse together.
- d) attractive forces just overcome repulsive forces.
- e) I don't know. Please give me a half point.

(j) Which of the following is a physical process?

- a) ionization of potassium  $e^-$  transfer
- b) combustion of methane  $e^-$  transfer
- c) dilution of hydrochloric acid
- d) reduction of sulfate  $e^-$  transfer
- e) I don't know. Please give me a half point.

2) (12 points) A sample of phosphorus weighing 17.36 g completely reacts with oxygen to form 39.77 g of a phosphorus/oxygen compound. Calculate the empirical (simplest) formula for the compound and give the name of the compound. *Think about the 4g tab*

39.77g compound  
17.36g phosphorus  

---

22.41g oxygen

*PO<sub>3</sub> ← X PO<sub>2.5</sub> → P<sub>2</sub>O<sub>5</sub>*  
empirical formula and name of compound  
*simplest whole # ratio*  
diphosphorus pentoxide

$$\frac{22.41 \text{ g O}}{16.00 \text{ g O}} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 1.401 \text{ mol O} \quad \frac{17.36 \text{ g P}}{30.97 \text{ g P}} \times \frac{1 \text{ mol P}}{30.97 \text{ g P}} = 0.5605 \text{ mol P}$$

extra

$$\frac{1.401 \text{ mol}}{0.5605 \text{ mol}} = 2.500 \text{ O} \quad \frac{0.5605 \text{ mol}}{0.5605 \text{ mol}} = 1.000 \text{ P} \quad \text{P}_1\text{O}_{2.5} \rightarrow \text{P}_2\text{O}_5$$

3) (8 points) Complete the following table of isotopes, assuming all neutral atoms.

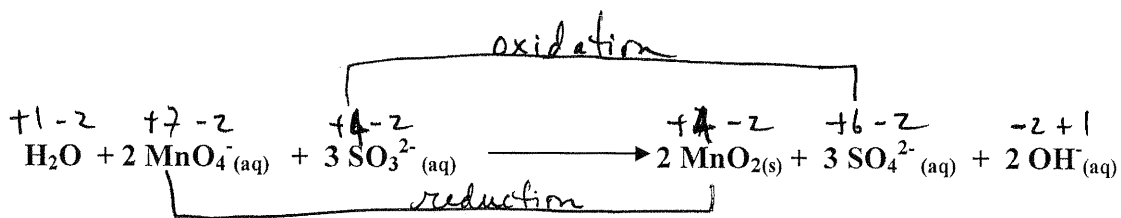
Symbol	$^{62}_{28}\text{Ni}$	$^{185}_{54}\text{Xe}$
Protons	28	54
Neutrons	34	131
Atomic Number	28	54
Mass Number	62	185

4) (6 points) The density of water is 1.00 g/mL. What is the molarity of pure water?

$$\frac{1.00 \text{ g } \cancel{\text{H}_2\text{O}}}{1. \cancel{\text{mL}} \text{ H}_2\text{O}} \times \frac{1 \text{ mol } \text{H}_2\text{O}}{18.02 \text{ g } \cancel{\text{H}_2\text{O}}} \times \frac{1000 \cancel{\text{mL}}}{1 \text{ L}} = 55.5 \frac{\text{mol}}{\text{L}}$$

$$= 55.5 \text{ M}$$

5) (10 points) For the following reaction write the correct oxidation state number above each element and identify the chemical species that are reduced and oxidized.

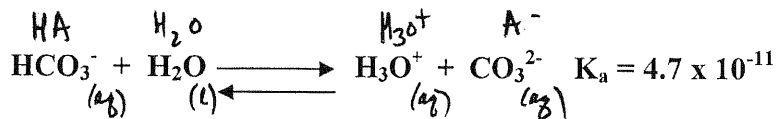


species oxidized  $\text{SO}_3^{2-}$

species reduced  $\text{MnO}_4^-$

6) (20 points)

a) (8 points) Bicarbonate dissociates in water according to the following equation:



a) Which side of the equilibrium is favored? Why?

Reactants  $K_a \ll 1$

b) At equilibrium, a bicarbonate solution contains  $9.6 \times 10^{-10}$  moles of  ~~$\text{CO}_3^{2-}$~~   $\text{H}_3\text{O}^+$ . The volume of the solution is 400.0 mL. Calculate the pH of this solution.

At equilibrium for every  $\text{HCO}_3^-$  that reacts with  $\text{H}_2\text{O}$ , 1  $\text{H}_3\text{O}^+$  and 1  $\text{CO}_3^{2-}$  are made,

$$\text{so } [\text{CO}_3^{2-}] = \frac{9.6 \times 10^{-10} \text{ mol}}{0.400 \text{ L}} = [\text{H}_3\text{O}^+]$$

$$\text{pH} = -\log [\text{H}_3\text{O}^+] = -\log(2.4 \times 10^{-9}) = 8.62 \text{ basic}$$

b) (3 points) What effect would the addition of  $\text{Na}_2\text{CO}_3$  have on the equilibrium? Explain.

Adding  $\text{Na}_2\text{CO}_3$  adds  $\text{CO}_3^{2-}$ . This would shift the above equilibrium to the left according to Le Chatelier's Principle

c) (6 points) Calculate the pH of a bicarbonate buffer solution containing 0.0046 M  $\text{HCO}_3^-$  and 0.0051 M  $\text{CO}_3^{2-}$ . Start this problem by writing the symbolic form of  $K_a$ .

$$\text{pH} = \text{p}K_a + \log \frac{[\text{CO}_3^{2-}]}{[\text{HCO}_3^-]}$$

$$\text{pH} = \text{p}K_a + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

$$\text{pH} = -\log(4.7 \times 10^{-11}) + \log \left( \frac{0.0051}{0.0046} \right)$$

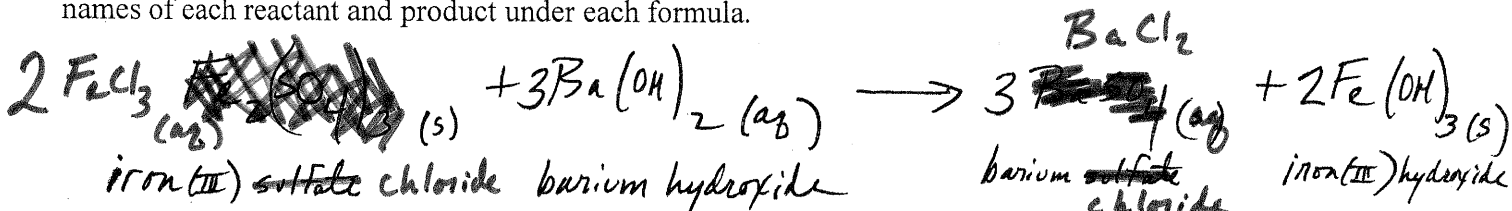
$$\text{pH} = 10.33 + 0.04 = 10.37$$

d) (3 points) What effect would the addition of  $\text{Na}_2\text{CO}_3$  have on the pH of the buffer solution? Explain.

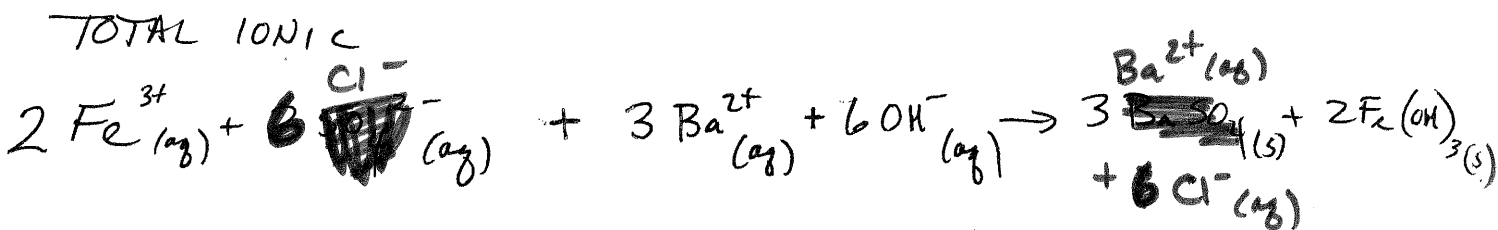
adding  $\text{CO}_3^{2-}$  will increase the pH, but only slightly since the buffer can adjust to this addition, keeping the pH about the same as it was.

7) (20 points) A solution containing 4.65 g of  $\text{FeCl}_3$  is added to a solution containing excess  $\text{Ba}(\text{OH})_2$ .

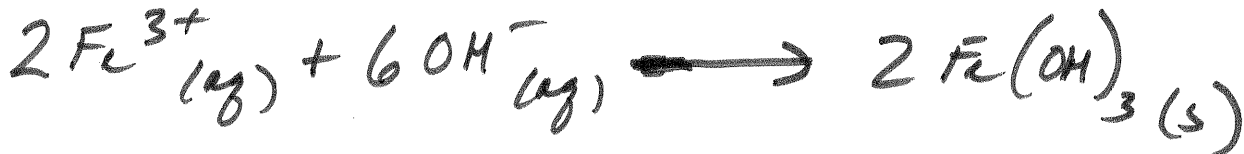
a) Write a balanced equation for this reaction. Include proper phase notation, i.e. (aq), (s), (l). Write the names of each reactant and product under each formula.



b) Write the balanced total ionic and net ionic equations for this reaction. Include proper phase notation, i.e. (aq), (s), (l).



NET IONIC ~~IS THE SAME SINCE THE NET IONIC COMPOUNDS ARE BOTH INSOLUBLE~~



c) What is the predicted yield of iron(II) hydroxide?

4.65 g $\text{FeCl}_3$	1 mol $\text{FeCl}_3$	2 mol $\text{Fe}(\text{OH})_3$	106.88 g $\text{Fe}(\text{OH})_3$
1	162.21 g $\text{FeCl}_3$	2 mol $\text{FeCl}_3$	1 mol $\text{Fe}(\text{OH})_3$
<del>248 g <math>\text{Fe}(\text{OH})_3</math></del> <u>3.064</u>			

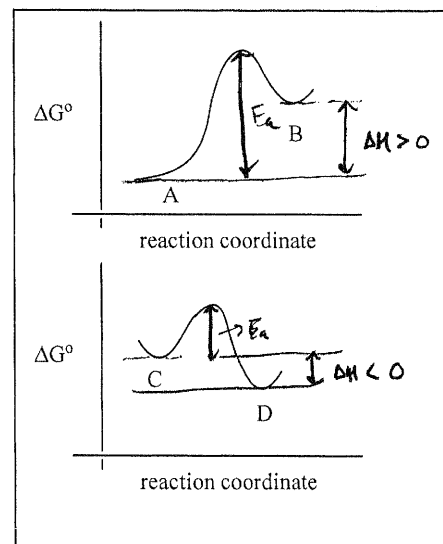
8) (10 points) Write the complete electron configuration and indicate the number of valence electrons for the following:

species		electron configuration	# of valence electrons
Ga	31 e <sup>-</sup>	1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>6</sup> 3s <sup>2</sup> 3p <sup>6</sup> (4s <sup>2</sup> )3d <sup>10</sup> (4p <sup>1</sup> )	3
K <sup>+</sup>	18 e <sup>-</sup>	1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>6</sup> (3s <sup>2</sup> )(3p <sup>6</sup> )	8
C <sup>2-</sup>	8 e <sup>-</sup>	1s <sup>2</sup> (2s <sup>2</sup> )(2p <sup>4</sup> )	6

9) (8 points) The reaction coordinates for two separate reactions (A → B and C → D) are shown at the right. Answer the following questions assuming that the reaction proceeds from left to right (forward).

Circle your choice

- a) Which reaction is an endo<sup>o</sup>thermic<sup>g</sup> reaction, A/B or C/D?
- b) Which reaction is faster, A/B or C/D?
- c) Which reaction is most likely reversible, A/B or C/D?
- d) Which reaction could use the help of a catalyst, A/B or C/D?



10) (6 points) Draw the Lewis dot structure for BF<sub>2</sub>I. To what geometry family does this molecule belong? What is the actual geometry of this molecule? Is this molecule polar? What intermolecular forces occur between molecules? Be sure to label all atoms with correct partial charges and show the dipole moment.

