

Name: _____
Chemical Principles I

June 21, 2012
Final Exam

The value of some useful constants: speed of light, c , 3.00×10^8 m/s $h = 6.626 \times 10^{-34}$ J•s

$$R = 0.08206 \frac{L \cdot atm}{mol \cdot K} \quad K = (^\circ C + 273.15^\circ C) \left(\frac{1 K}{1^\circ C} \right) \quad 1 J = 1 kg \cdot m^2 / s^2 \quad \Delta E = h\nu$$

$$N_A = 6.022 \times 10^{23} \quad 1 \text{ mm of Hg} = 1 \text{ torr} \quad 1 \text{ atm} = 760 \text{ torr} \quad PV = nRT \quad 1 \text{ nm} = 10^{-9} \text{ m}$$

$$1 \text{ Hz} = 1 \text{ s}^{-1} \quad 1 \text{ \AA} = 10^{-10} \text{ m} \quad \lambda\nu = c \quad P_A = X_A P_A^\circ \quad \chi_a = \frac{n_a}{n_a + n_b + \dots}$$

$$P_a = \chi_a P_{total} \quad M = \frac{dRT}{P} \quad FC = \text{Group\#} - \left(\# \text{ unshared } e^- \right) - \frac{1}{2} \left(\# \text{ shared } e^- \right)$$

Show all of your work. Beware of the charges on ions. Check your significant figures.
Problems are worth 2 points each except where indicated.

Name the following compounds

1. $Fe(NO_2)_2$ Iron (II) nitrite

2. Cl_2O_7 dichlorine heptoxide

Give the formula for the following compounds

3. Nitric acid HNO_3

4. Sulfuric acid H_2SO_4

5. Which element would be expected to have chemical and physical properties closest to those of carbon?

A) B

B) N

C) S

D) Si

E) Cl

6. Nitrogen forms an ion with a charge of _____.

A) +2

B) -3

C) +1

D) +3

E) -1

7. An atom of the most common isotope of gold, $^{197}_{79}\text{Au}$, has 79 protons, 118 neutrons, and 79 electrons.

A) 197, 79, 118

B) 118, 79, 39

C) 79, 197, 197

D) 79, 118, 118

E) 79, 118, 79

8. Isotopes are atoms that have the same number of p^+ but differing number of n^0 .

A) protons, electrons

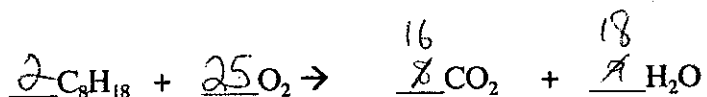
B) neutrons, protons

C) protons, neutrons

D) electrons, protons

E) neutrons, electrons

9. Balance the following equation



10. A compound contains 40.0% C, 6.71% H, and 53.29% O by mass. The molecular weight of the compound is 60.05 amu. The molecular formula of this compound is $\text{C}_2\text{H}_4\text{O}_2$. (2 pt)

A) $\text{C}_2\text{H}_4\text{O}_2$

B) CH_2O

C) $\text{C}_2\text{H}_3\text{O}_4$

D) $\text{C}_2\text{H}_2\text{O}_4$

E) CHO_2

- 58-44
126.75
11. How many grams of sodium chloride can be formed when 25 grams of iron(II)chloride react with 50 grams of sodium phosphate according to the following balanced chemical equation?

(2pt)



- a) 13 g **b) 23 g** c) 33 g d) 50 g e) 75 g

$$25\text{g FeCl}_2 \times \frac{1\text{ mol FeCl}_2}{126.75\text{g FeCl}_2} \times \frac{6\text{ mol NaCl}}{3\text{ mol FeCl}_2} = 0.394\text{ mol NaCl} \times \frac{58.44\text{g/mol}}{1\text{ mol}} = 23.0\text{g}$$

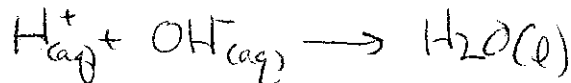
$$50\text{g Na}_3\text{PO}_4 \times \frac{1\text{ mol Na}_3\text{PO}_4}{223.94\text{g Na}_3\text{PO}_4} \times \frac{6\text{ mol NaCl}}{2\text{ mol Na}_3\text{PO}_4} = 0.670\text{ mol}$$

12. Identify the following as strong electrolytes (strong), weak electrolytes (weak), or nonelectrolytes (non). (2 pt)

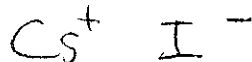
a. HCl **strong** weak non

b. NH₃ strong **weak** non

13. Write the net ionic equation for the reaction between CsOH (aq) and HI (aq).



14. What are the spectator ions in the reaction between CsOH (aq) and HI (aq)?



15. Which hydroxides are strong bases?

CsOH KOH NaOH Ba(OH)₂

A) KOH, Ba(OH)₂

B) KOH, NaOH

C) KOH, NaOH, Ba(OH)₂

D) CsOH, KOH, NaOH, Ba(OH)₂

E) None of these is a strong base.

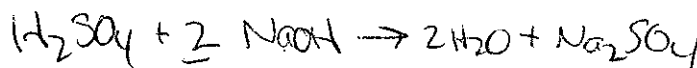
16. What volume (mL) of a concentrated solution of sodium hydroxide (6.00 M) must be diluted to 200 mL to make a 0.88 M solution of sodium hydroxide?

- A) 2.64 B) 176 C) 26.4 D) 29.3 E) 50.0

$$\cancel{H_2SO_4} + \underline{2} \quad V_1 = \frac{(200 \text{ mL})(0.88 \text{ M})}{6.00 \text{ M}} = \underline{29.3 \text{ mL}}$$

17. A 31.5 mL aliquot of H_2SO_4 (aq) of unknown concentration was titrated with 0.0134 M NaOH (aq). It took 23.9 mL of the base to reach the endpoint of the titration. The concentration (M) of the acid was _____.

- A) 0.0102 B) 0.0051 C) 0.0204 D) 0.102 E) 0.227



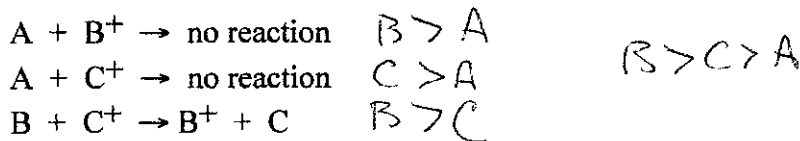
$$23.9 \text{ mL NaOH} \times \frac{L}{1000 \text{ mL}} \times \frac{0.0134 \text{ mol NaOH}}{L} \times \frac{1 \text{ mol } H_2SO_4}{2 \text{ mol NaOH}} = 1.60 \times 10^{-4} \text{ mol}$$

$$\frac{1.60 \times 10^{-4} \text{ mol}}{0.0315 \text{ L}} = 0.0051 \text{ M}$$

18. Indicate if the following are soluble or insoluble in water at 25°C? (2 pt)

- a) AgCl soluble insoluble
- b) Na_2CO_3 soluble insoluble

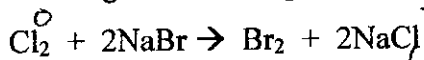
19. Consider the following reactions:



Which is the correct order of increasing activity for these metals?

- A) $A > B > C$ B) $A > C > B$ C) $B > C > A$ D) $B > A > C$ E) $C > B > A$

20. Considering the following reaction, what is undergoing reduction?



- a) Na b) Na and Br₂ c) Br⁻ **d) Cl₂** e) Na⁺

21. A gas mixture of Ne and Ar has a total pressure of 4.00 atm and contains 16.0 mol of gas. If the partial pressure of Ne is 2.75 atm, how many moles of Ar are in the mixture?

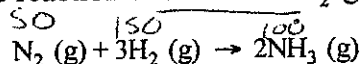
- A) 11.0 B) 5.00 C) 6.75 D) 9.25 E) 12.0

$$P_{\text{tot}} = 4.00 \quad P_{\text{Ne}} = 2.75 \quad X_{\text{Ar}} = 1 - 0.6875 = 0.3125$$

$$n_{\text{tot}} = 16.0 \text{ mol} \quad X_{\text{Ne}} = \frac{P_{\text{Ne}}}{P_{\text{tot}}} = \frac{2.75}{4.00} = 0.6875 \quad n_{\text{Ar}} = n_{\text{tot}} \times X_{\text{Ar}}$$

$$(16.0)(0.3125) = 5 \text{ mol}$$

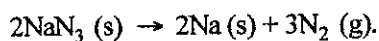
22. The reaction of 50 mL of N₂ gas with 150 mL of H₂ gas to form ammonia via the equation:



will produce _____ mL of ammonia if pressure and temperature are kept constant.

- A) 250 B) 50 C) 200 D) 150 **E) 100**

23. Automobile air bags use the decomposition of sodium azide as their source of gas for rapid inflation:



What mass (g) of NaN₃ is required to provide 40.0 L of N₂ at 25.0 °C and 763 torr?

- A) 1.64 B) 1.09 C) 160 **D) 71.1** E) 107

$$n = \frac{PV}{RT} = \frac{(763/760)(40.0\text{L})}{(0.08206)(298.2\text{K})} = 1.64 \text{ mol N}_2$$

$$1.64 \text{ mol N}_2 \times \frac{2 \text{ mol NaN}_3}{3 \text{ mol N}_2} \times \frac{65.02 \text{ g NaN}_3}{1 \text{ mol NaN}_3} = 71.1 \text{ g NaN}_3$$

24. A gas originally at 27 °C and 1.00 atm pressure in a 3.9 L flask is cooled at constant pressure until the temperature is 11 °C. The new volume of the gas is _____ L.

- A) 0.27 **B) 3.7** C) 3.9 D) 4.1 E) 0.24

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad V_2 = \frac{V_1 T_2}{T_1} = \frac{(3.9 \text{ L})(284 \text{ K})}{300 \text{ K}} = 3.7 \text{ L}$$

25. The molecular weight of a gas that has a density of 6.70 g/L at STP is _____ g/mol.

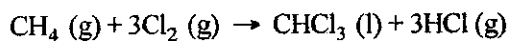
- A) 496 **B) 150** C) 73.0 D) 3.35 E) 0.298

$$M = \frac{dRT}{P} = \frac{(6.70 \frac{\text{g}}{\text{L}})(0.08206 \frac{\text{L atm}}{\text{mol K}})(273 \text{ K})}{1.00 \text{ atm}} = 150 \frac{\text{g}}{\text{mol}}$$

26. Which one of the following gases would have the highest average molecular speed at 25 °C?

- | | | | | |
|-------------------------------|-------------------------|--------------------------|--------------------------|---------------------------|
| A) O₂
32 | B) F ₂
38 | C) Cl ₂
71 | D) CF ₄
88 | E) SF ₆
116 |
|-------------------------------|-------------------------|--------------------------|--------------------------|---------------------------|

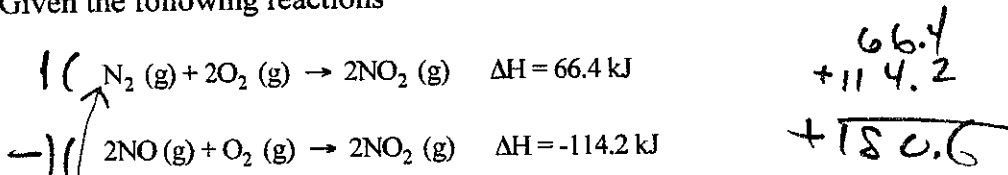
27. The value of ΔH° for the reaction below is -336 kJ. Calculate the heat (kJ) released to the surroundings when 23.0 g of HCl is formed.



- A) 177 B) 2.57×10^3 **C) 70.7** D) 211 E) -336

$$23.0 \text{ g HCl} \times \frac{1 \text{ mol HCl}}{36.46 \text{ g HCl}} \times \frac{-336 \text{ kJ}}{3 \text{ mol HCl}} = 70.7 \text{ kJ}$$

28. Given the following reactions



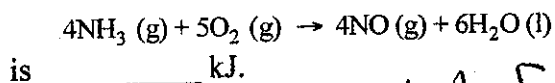
the enthalpy of the reaction of the nitrogen to produce nitric oxide



is _____ kJ.

- A) 180.6** B) -47.8 C) 47.8 D) 90.3 E) -180.6

29. Given the data in the table below, $\Delta H^\circ_{\text{rxn}}$ for the reaction



Compound	ΔH_f° , kJ/mol
NH ₃ (g)	-46.11
NO(g)	+90.25
H ₂ O(l)	-285.8
HNO ₃ (aq)	-207.36

$$\begin{aligned} \Delta A &= [4(+90.25) + 6(-285.8)] - [4(-46.11) + 5(0)] \\ &= -1353.8 - (-184.44) \\ &= -1169.36 \text{ kJ} \end{aligned}$$

- A) -1169** B) -150 C) -1540 D) -1892
 E) The ΔH_f° of O₂(g) is needed for the calculation.

30. A mole of yellow photons of wavelength 527 nm has _____ kJ of energy.

- A) 165 **B) 227** C) 4.56×10^{-46} D) 6.05×10^{-3} E) 2.74×10^{-19}

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34} \text{ J}\cdot\text{s}) (3.00 \times 10^8 \frac{\text{m}}{\text{s}})}{(527 \times 10^{-9} \text{ m})} = 3.77 \times 10^{-19} \text{ J}$$

$$3.77 \times 10^{-19} \frac{\text{J}}{\text{photon}} \times \frac{6.022 \times 10^{23} \text{ photons}}{\text{mol}} = 227 \frac{\text{kJ}}{\text{mol}}$$

31. S-orbitals are spherically symmetrical.

- A) f B) d C) p D) s E) g

32. Which quantum number determines the energy of an electron in a hydrogen atom?

- A) l B) m_s C) m_l D) n E) n and l

33. At maximum, an f-subshell can hold 14 electrons, a d-subshell can hold 10 electrons, and a p-subshell can hold 6 electrons.

A) 14, 10, 6

B) 2, 8, 18

C) 14, 8, 2

D) 2, 12, 21

E) 2, 6, 10

34. Which group in the periodic table contains elements with the valence electron configuration of ns^2np^3 _____?

A) 1A

B) 2A

C) 3A

D) 4A

E) 5A

35. Which one of the following atoms has the largest radius?

~~A) Br~~

B) As

C) Se

D) Ga

E) Ge

36. Of the following atoms, which has the largest first ionization energy?

A) Si

B) B

C) C

D) P

E) N

37. Which of the following has the largest increase between the fourth and fifth ionization energies?

A) Si

B) Mg

C) Al

D) Na

E) P

38. Which ion below has the largest radius?

- A) O^{2-} B) Mg^{2+} C) Na^+ D) Al^{3+} E) F^-

39. Of the following elements, _____ has the greatest electron affinity.

- A) B B) Li C) F D) O E) N

40. Which one of the following compounds would produce an acidic solution when dissolved in water?

- A) K_2O B) CaO C) MgO D) NO_2 E) SrO

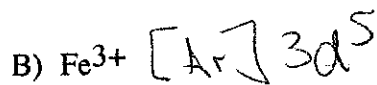
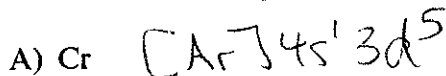
41. Which of the elements below has the largest electronegativity?

- A) Cl B) O C) S D) Br E) F

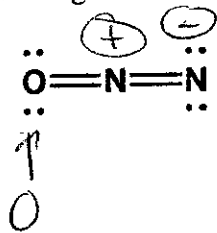
42. Which of the following compounds has the greatest lattice energies:

- A) LiF B) Mg_3N_2 C) MgCl_2 D) CsI E) CaCl_2

43. Give the electron configurations of the following atoms and ions; (4 pt)



44. Assign formal charges to all atoms in the molecule below: (2 pt)



$$\text{FC}_{\text{O}} = 6 - 4 - \frac{1}{2}(4) = 0$$

$$\text{FC}_{\text{=N}} = 5 - 0 - \frac{1}{2}(8) = +1$$

$$\text{FC}_{\text{=N}} = 5 - 4 - \frac{1}{2}(4) = -1$$

45. Complete the following table. (6 pts)

Compound	Lewis Structure*	Molecular geometry	Hybridization of central atom
NH ₃	$\begin{array}{c} \text{H} - \overset{\cdot\cdot}{\underset{\cdot\cdot}{\text{N}}} - \text{H} \\ \\ \text{H} \end{array}$	trigonal pyramidal	sp ³
NO ₂ ⁻	$\begin{array}{c} \overset{\cdot\cdot}{\text{O}} = \overset{\cdot\cdot}{\underset{\cdot\cdot}{\text{N}}} - \overset{\ominus}{\underset{\cdot\cdot}{\text{O}}} \\ \cdot\cdot \quad \cdot\cdot \quad \cdot\cdot \end{array}$	bent	sp ²

*If a compound has resonance structures, choose one structure to base your answers on.

Use the following molecular orbital diagram to answer the following two questions. Note that for simplicity the σ_{1s} and σ^*_{1s} are omitted.

46. What is the bond order of the O₂ molecule? (2 pt)

- A) 0 B) 1/2 C) 1 **(D) 2** E) 3

$$BO = \frac{1}{2}(8 - 4) = 2$$

47. What are the magnetic properties of O₂? (2 pt)

A) Diamagnetic

B) Paramagnetic

