Name:_____

Score: /60

Note: A Periodic Table is provided for reference at the end.

Section 1: Thermodynamics

1. Which of the following is not a state function?
   (a) Energy (b) Enthalpy (c) Work (d) Pressure (e) Volume (f) Helmholtz Free Energy

2. At constant pressure and volume and at 300 K, a reaction has $\Delta G = 0.15$, while at 3000 K, a reaction has $\Delta G = 20.$ What can we conclude about this reaction?
   (a) The reaction will be spontaneous at 100K (b) There is a change in state of matter
   (c) The reaction will be spontaneous at 200K (d) $\Delta H < 0$

3. Which of the following elements could have a negative heat of fusion at 1 atm pressure?
   (a) Hydrogen (b) Helium (c) Lithium (d) Beryllium (e) Iodine (f) Phosphorous

4. A system of ideal nitrogen gas is compressed at constant temperature. What are the signs of work and heat in this compression? (W,Q) =
   (a) (+,+) (b) (+,-) (c) (-,+) (d) (-,-)

5. What is the high temperature limiting molar heat capacity of diatomic gases (R = gas constant)?
   (b) R (c) 3R/2 (d) 2R (e) 5R/2 (f) 3R (g) 7R/2 (h) 4R (i) 9R/2 (j) 5R (k) 4R/3 (l) 8R/3

6. From the definition of entropy and the second law of thermodynamics, derive the fact that spontaneous reactions will only occur when $\Delta G \leq 0$ [You may assume constant pressure]

7. A calorimeter at $23^{\circ}C$ has a heat capacity of $100\, J/C^{\circ}$ and is filled with 30.1 L of water at $30^{\circ}C$. Afterwards, a piece of 2.01 g iron (heat capacity: 0.45 J/(g K)) at $700^{\circ}C$ is dropped into the calorimeter. Find the final temperature after equilibrium is established. Assume no heat is lost.

8. Explain why humans can and still exist, despite the laws of thermodynamics.

9. According to the Dulong–Petit law, the molar heat capacity of many elements is $3R$, where R is the gas constant.
   (a). Calculate the molar heat capacity of iron, given that its heat capacity is 0.45 J/(g K)

   (b). Calculate the molar heat capacity of water, given that its heat capacity is 4.2 J/(g K)

   (c). Explain the cause(s) of any significant deviations from the Dulong-Petit law from parts (a) and (b). If there are no significant deviations, then do not answer this question.

10. If 1 g iron at 100 K is dissolved into a beaker with 1 g water at 200 K, then what will be the final temperature after equilibrium is established?

11. [Tiebreaker] For an ideal gas, it is well known that $C_p - C_v = nR$, where n is the moles of substance, and C_p and C_v are the molar heat capacities at constant pressure and constant volume, respectively. Given that the internal energy of an ideal gas only depends on temperature, prove the above relation between C_p and C_v.

12. [Tiebreaker] 1 mol of an ideal gas is at a temperature of 300 K, and inside of an expandable 1 L container. If the container started increasing by 1 L/sec, and temperature is kept constant throughout this expansion, then at what rate is the container's pressure changing when the container is at 10 L? Assume no loss of energy or loss of molecules.

Section 2: Physical Properties

13. A 10 mL solution of CuCl2 in water is diluted to 1 L. If the freezing point of the first solution, before dilution, is -5.58 C, then find the freezing point of the solution after dilution.

14. Which of the following would have the highest boiling point?
    (a) n-octane (b) water (c) sodium chloride (d) diamond (e) 2-propanol

15. Which of the following salts would produce a colorless solution when dissolved?
    (a) $Zn(NO_3)_2$ (b) $K_2Cr_2O_7$ (c) $BaSO_4$ (d) $CuCl_2$ (e) $KMnO_4$ (f) NaI

16. An unknown metal is subjected to a flame test and produces a crimson red color. It is then combined with AgCl in solution and the resulting solution precipitates out Ag. Adding excess KNa2PO4 to this solution results in the formation of another precipitate. What is this metal?
    (a) Li (b) Na (c) K (d) Au (e) Ca (f) Mg (g) Sr

17. Caesium Fluoride adopts a cubic close packed lattice structure in its crystal form, with unit cell length of 624 angstroms. Find its density.

18. Which of the following compounds, when combined together, would likely produce a non-brittle compound?
    (a) $NaNO_3 + KCl$ (b) $CF_3SO_3H + NaH$ (c) $Ag + Mg(OH)_2$ (d) $AgNO_3 + CuCl_2$

19. Which of the following solids would easily sublime? (circle all that apply)
    (a) CO_2 (b) Naphthalene (c) I_2 (d) p-Toluenesulfonic acid

20. Which of the following liquids would have the highest dielectric constant?
    (a) Benzene (b) Diethyl ether [ethoxyethane] (c) Water (d) HCl

21. Explain how a mixture of the following liquids could be separated:
    Ammonia, Water, Lauric Acid (bp 300 C), Benzene

22. Explain how a mixture of iron, gold, and pulverized balsa wood can be separated.

23. Vulcanization of rubber is a common process used in order to make rubber much more elastic than natural rubber. Describe what this process does to the rubber's chemical structure.

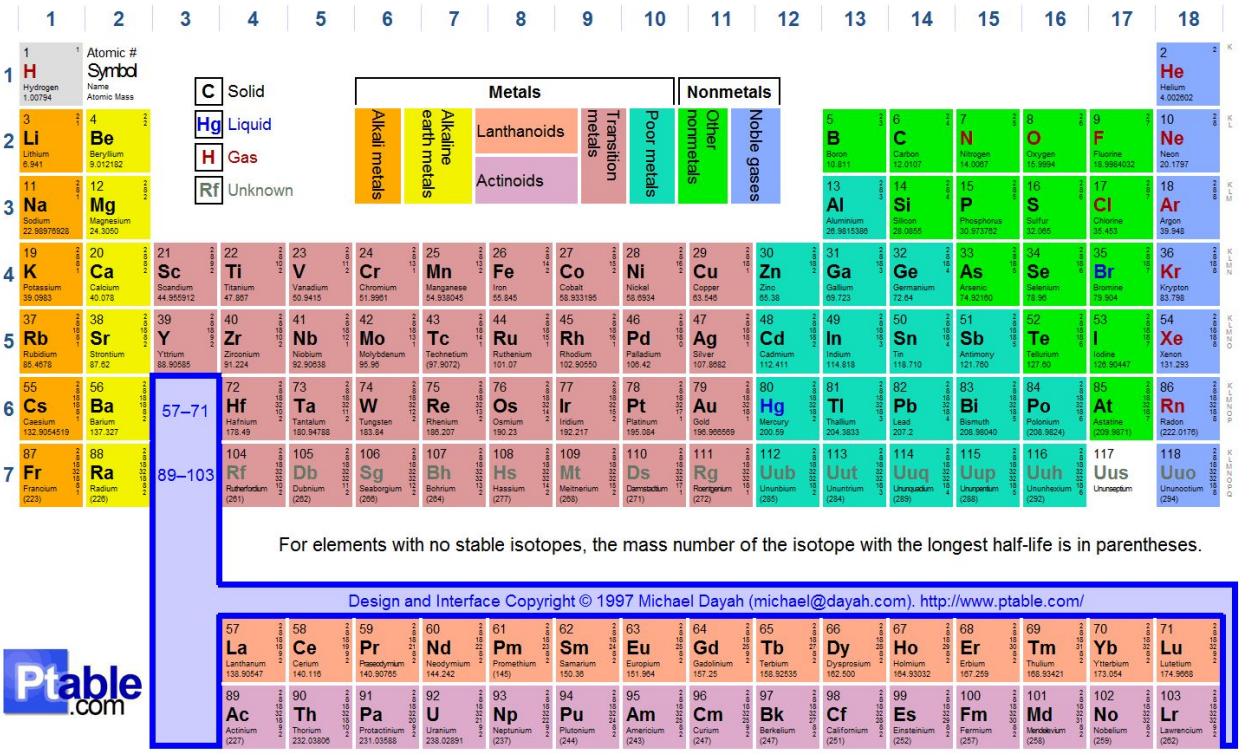
24. Dichromate ions can be converted to chromate ions through an acid catalyst. Provide a way to qualitatively see that this change has occurred. (Be specific)

25. A solution of a non-electrolyte, x, contains 42 grams of x per kilogram of water and freezes at -1.46°C. What is the molecular weight of x?

26. A piece of silver foil has a width of 2.00 cm and is 0.00200 in. thick. If the density of silver is 10.5 g/cm3, how long of a strip should be cut to obtain 1.00 g of the metal?

27. Which substance is most soluble in water?
    (a) glucose (b) ethanol (c) octanol (d) benzene (e) 1-methylcyclopropene

Periodic Table of Elements



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