Chem 1A
Test #2 Review

1. Name each of the following compounds:

(a) $Ca(OCl)_2$: ______________________;
(b) $(NH_4)_3PO_4$: ______________________;
(c) $K_2Cr_2O_7$:________________________;
(d) $HBrO_2$:_____________________;
(e) PF_5:______________________;
(f) B_2O_3 : ___________________________;
(g) $Fe(OH)_3$:________________________;
(h) $Cr(NO_3)_3$:________________________;
(*i*) $Na_2C_2O_4$:________________________;
(j) $CuSO_4•5H_2O$:________________________.

2. Write the correct formula of each of the following compounds:

(a) Aluminum carbonate: ________;
(b) Lead(II) chromate: ________;
(c) Chromium(III) sulfate:___________;
(d) Lead(II) nitrate: ________;
(e) Sodium hydrogen phosphate:________;
(f) Perchloric acid:__________
(g) Potassium permanganate: ________
(h) Dinitrogen tetroxide: ________
(*i*) Diphosphorus pentasulfide: ________
(j) Nickel(II) chloride hexahydrate:__________

3. Write a balanced equation for each reaction described below:

(a) Solid ammonium dichromate decomposes when heated to form solid chromium(III) oxide, nitrogen gas, and water vapor.

(b) Calcium metal reacts with liquid water to yield calcium hydroxide solution and hydrogen gas.

4. Balance the following chemical equations.

(a) $C_2H_5OH(l) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$;

(b) $PH_3(g) + O_2(g) \rightarrow P_2O_5(s) + H_2O(l)$;

(c) $Ba(NO_3)_2(aq) + Na_3PO_4(aq) \rightarrow Ba_3(PO_4)_2(s) + NaNO_3(aq)$

5. Assign oxidation numbers (o.n.) to elements underlined in each of the following compounds:

(a) Na**<u>N</u>**O_2 (b) Na_2**<u>S</u>**$_2O_3$ (c) K_2**<u>Cr</u>**$_2O_7$ (d) H**<u>Cl</u>**O_4

6. Balance the following redox reactions in acidic solutions using half-equation method:

(a) $Cr_2O_7^{2-}(aq) + H_2O_2(aq) \rightarrow Cr^{3+}(aq) + O_2(g)$;

(b) $MnO_4^-(aq) + H_2C_2O_4(aq) \rightarrow Mn^{2+}(aq) + CO_2(g)$

7. Balance the following redox reactions in basic solutions using half-equation method:

(a) $Cr(OH)_4^-(aq) + H_2O_2(aq) \rightarrow CrO_4^{2-}(aq) + H_2O(l)$;

(b) $MnO_4^-(aq) + NO_2^-(aq) \rightarrow MnO_2(s) + NO_3^-(aq)$

8. A 0.5116-g sample of potassium hydrogen phthalate (abbreviated as "KHP"; formula: $KHC_8H_4O_4$; molar mass = 204.22 g/mol) is dissolved in enough deionized water to make a 50.00 mL solution. The solution is completely titrated with NaOH solution using phenolphthalein as indicator to determine the accurate end-point. The acid-base reaction occurs according to the following equation:

$$KHC_8H_4O_4(aq) + NaOH(aq) \rightarrow NaKC_8H_4O_4(aq) + H_2O(l);$$

(a) Calculate the initial molarity of the KHP solution.
(b) If 21.50 mL of NaOH solution were required to neutralize the acid, what is the molar concentration of NaOH solution?

9. The molar concentration of H_2SO_4 in a battery fluid was determined by titration with NaOH solution of known concentration. A 5.00-mL sample of battery fluid was first diluted with deionized water to 100.0 mL, and a 10.00-mL portion of this dilute acid solution was titrated with 0.1165 *M* NaOH solution. The acid-base reaction occurs as follows:

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(a) If 36.20 mL 0.1165 *M* NaOH were required to neutralize the dilute acid solution, calculate the molar concentration of H_2SO_4 in the dilute acid solution?
(b) Determine the molarity of H_2SO_4 in original battery fluid.

10. Silver bromide, AgBr, is prepared by the following precipitation reaction:

$$AgNO_3(aq) + NaBr(aq) \rightarrow AgBr(s) + NaNO_3(aq)$$

(a) A 250.0-mL sample of 0.150 *M* $AgNO_3$ solution is reacted with 125.0 mL of 0.400 *M* NaBr solution. Which is the limiting reactant?
(b) If the limiting reactant is completely reacted and the yield is 100%, how many grams of AgBr will be produced?
(c) Calculate the percent yield if 6.52 g of AgBr were obtained?

11. Indicate whether each of the following compounds will form *strong electrolyte*, *weak electrolyte*, or *non-electrolyte*, in aqueous solution:

(a) $Al(NO_3)_3$	(b) $BaCl_2$	(c) CH_3OH	(d) $HClO_2$	(e) $HClO_4$	(f) $HC_2H_3O_2$
(g) HCl	(h) KOH	(*i*) H_3PO_4	(j) $C_2H_6O_2$	(k) NH_4NO_3	(*l*) NH_3

12. A system absorbs 35.0 kJ of heat as it expands from 36.0 mL (0.0360 L) to 27.7 L against a constant pressure of 1.50 atm. (a) Calculate the amount of work done in L.atm and in kJ; assign appropriate algebraic sign (+ or -) to the work value. Is work done by the system or on the system? (b) Calculate the internal energy change (ΔE) of the system. (1 L.atm = 0.1013 kJ)

13. If 40.0 g of hot water at 80.0°C is added to 60.0 g of cold water at 20.0°C, what is the final temperature of the mixture? Assume heat lost to the surrounding or absorbed by calorimeter is negligible. (Specific heat of water = 4.184 J/g.°C)

14. 50.0 g of water at 64.0°C is added to cold water of unknown mass at 22.0°C. If the final temperature of the mixture is 37.0°C, what is the mass of cold water? (Specific heat of water = 4.184 J/g.°C)

15. A 56.5-gram sample of metal at 100.0°C is added to 50.0 g of water at 21.0°C, and the final temperature of water and metal is 28.5°C. Calculate the specific heat of metal. The specific heat of water is 4.184 J/g.°C; assume heat absorbed by calorimeter and lost to the surroundings is negligible.

16. A 1.110-g sample of benzoic acid ($HC_7H_5O_2$; molar mass = 122.12 g/mol) is burned in an excess of O_2(g) in a bomb calorimeter, which is immersed in water. The reaction produces heat that causes the temperature of the water and bomb to increase from 21.90 to 26.15°C. The calorimeter contains 1.45 kg of water and the "bomb" has heat capacity 833 J/°C. (a) Calculate the amount of heat (in kJ) absorbed by the water and "bomb", respectively. (b) How much heat (in kJ) is produced by the combustion of 1.110-g sample of benzoic acid? (c) What is the heat of combustion per gram of benzoic acid? (d) Calculate the molar enthalpy of combustion of benzoic acid.

17. The following molar enthalpies of formation are given in kJ/mol:

$\Delta H_f^o[CH_3OH(l)] = -239.2$; $\Delta H_f^o[CO_2(g)] = -393.5$; $\Delta H_f^o[H_2O(g)] = -241.8$

(a) Calculate the enthalpy change (ΔH; in kJ) for the combustion of methanol, CH_3OH, according to the following equation.

$$2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(g);$$

(b) How many kilojoules of heat is produced burning 1.00 g of methanol?
(c) How much energy (in kJ) is required to heat 946 g of water from 21.0°C to 100.0°C?
(d) How many grams of methanol must be burned to provide enough energy that is required to heat the water in part (c)? (specific heat of water = 4.184 J/g.°C)

18. Given the following enthalpy of reactions:

(*i*) $2Fe(s) + {}^3/_2 O_2(g) \rightarrow Fe_2O_3(s)$; $\Delta H^o = -826$ kJ
(*ii*) $C(gr, s) + ½ O_2(g) \rightarrow CO(g)$; $\Delta H^o = -110.5$ kJ
(*iii*) $C(gr, s) + O_2(g) \rightarrow CO_2(g)$; $\Delta H^o = -393.5$ kJ

Calculate the enthalpy change for the following reaction:

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g); \quad \Delta H^o = ?$$

19. Using the enthalpy of formation of the following compounds:

$Si(s) + O_2(g) \rightarrow SiO_2(s)$;	$\Delta H^o = -910.9$ kJ
$Si(s) + 2F_2(g) \rightarrow SiF_4(g)$;	$\Delta H^o = -1614.9$ kJ
$H_2(g) + F_2(g) \rightarrow 2HF(g)$;	$\Delta H^o = -546.0$ kJ
$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$;	$\Delta H^o = -483.6$ kJ

Calculate the enthalpy change (ΔH^o) for the reaction of silicon dioxide with hydrogen fluoride gas given by the following equation:

$$SiO_2(s) + 4HF(g) \rightarrow SiF_4(g) + 2H_2O(g)$$

20. The *work function* of metal is the minimum energy required to produce photoelectric effect on that metal, and the *work function* for potassium metal is 2.30 eV (where 1 eV = 1.60×10^{-19} J).
(a) What is the minimum energy in Joules required to eject an electron from potassium metal?
(b) What is the longest wavelength of light, in nanometers (nm), capable of producing photoelectric effect on potassium metal?
(c) Determine whether a photon of green light with $\lambda = 512$ nm would have sufficient energy to eject an electron from a potassium metal. (d) If an electron is ejected, determine the kinetic energy and the speed of the ejected electron, which has a mass of 9.11×10^{-31} kg. .
(Planck's constant, $h = 6.626 \times 10^{-34}$ J·s.; speed of light, c = 3.00×10^8 m/s; 1 J = 1 kg·m^2/s^2)

21. What is the energy change (ΔE, in Joule) when an electron in hydrogen atom transitions from Bohr's orbit $n = 4$ to orbit $n = 2$? (b) Does the electron gain or lose energy? (c) Calculate the wavelength (λ, in nanometers) of the photon (absorbed or released) associated with the electron transition.
(Bohr's equation: $E_n = -2.18 \times 10^{-18}$ J/n^2; h = 6.626×10^{-34} J.s; c = 3.00×10^8 m/s)

22. Suppose that an electron acquires a kinetic energy of 1.50 eV (electron-volt). (a) What is the kinetic energy in Joule? (b) What is the velocity (in m/s) of this electron? (c) What is the de Broglie wavelength acquired by an electron traveling at this speed? ($m_e = 9.11 \times 10^{-31}$ kg; 1 eV = 1.60×10^{-19} J)

23. Assign a proper spectroscopic symbol (1s, 2s, 2p, etc.) to each subshell or orbital with the following sets of quantum numbers *n* and *l*. If any of the sets of quantum numbers are not allowed, please explain. For those that are allowed, determine the number of orbitals in each subshell and the maximum number of electrons that subshell or orbital can accommodate.

(a) n = 2, l = 1;
(b) n = 4, l = 3;
(c) n = 3, l = 3; m_l = 3;
(d) n = 6, l = 0;
(e) n = 5, l = 2;
(f) n = 3, l = 2, m_l = 1;

24. Write a complete electron configuration for each of the following atoms. DO NOT use the noble gas short-hand notation.

(a) Ca:

(b) Cl:

(c) Cu :

(d) Ni:

(e) Se:

25. Draw the orbital "box" diagram for the valence-shell electron configuration of the following atoms. (Use appropriate noble gas symbols to represent inner shell electrons.) Indicate whether the atom is diamagnetic or paramagnetic.

(a) N (Z = 7):

(b) Si (Z = 14):

(c) Cr (Z = 24):

(d) Zn (Z = 30):

(e) As (Z = 33):

26. In what group and period, respectively, will you find each atom having the following electron configuration? Which of these atoms belongs to the transition metal group?

(a) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$;

(b) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$;

(c) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^4$;

(d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2$;

(e) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3$;

(f) [Xe] $6s^2\ 4f^{14}\ 5d^{10}\ 6p^2$;

27. (a) <u>Describe</u> and <u>explain</u> the trends of atomic size and ionization energy in the Periodic Table: (*i*) from left to right across a period, and (*ii*) from top to bottom down a group.

(b) Rank the elements Na, Mg, Al, and K, in order of: (*i*) increasing atomic size; (*ii*) increasing ionization energy, and (*iii*) increasing reactivity.

(c) Rank the elements F, Cl, Br and I, in order of: (*i*) increasing atomic size; (*ii*) increasing electron affinity, and (*iii*) increasing reactivity.

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Answers:

1. (a) Calcium hypochlorite; (b) Ammonium phosphate; (c) Potassium dichromate; (d) Bromous acid (e) Phosphorus pentafluoride; (f) Diboron trioxide; (g) Iron(III) hydroxide; (h) Chromium(III) nitrate; (*i*) Sodium oxalate; (j) Copper(II) sulfate pentahydrate.

2. (a) $Al_2(CO_3)_3$ (b) $PbCrO_4$ (c) $Cr_2(SO_4)_3$ (d) $Pb(NO_3)_2$ (e) Na_2HPO_4 (f) $HClO_4$ (g) $KMnO_4$ (h) N_2O_4 (*i*) P_2S_5 (j) $NiCl_2.6H_2O$

3. (a) $(NH_4)_2Cr_2O_7(s) \rightarrow Cr_2O_3(s) + N_2(g) + 4H_2O(g)$;
(b) $Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(ag)$

4. (a) $C_2H_5OH(l) + \mathbf{3}\ O_2(g) \rightarrow \mathbf{2}\ CO_2(g) + \mathbf{3}\ H_2O(g)$;
(b) $\mathbf{4}PH_3(g) + \mathbf{8}\ O_2(g) \rightarrow \mathbf{2}\ P_2O_5(s) + \mathbf{6}\ H_2O(l)$;
(c) $\mathbf{3}Ba(NO_3)_2(aq) + \mathbf{2}Na_3PO_4(aq) \rightarrow Ba_3(PO_4)_2(s) + \mathbf{6}\ NaNO_3(aq)$;

5. Oxidation numbers (o.n.) of the elements that is underlined:
(a) $Na\underline{N}O_2$; N = +3 (b) $Na_2\underline{S_2}O_3$; S = +2 (c) $K_2\underline{Cr_2}O_7$; Cr = +6 (d) $H\underline{Cl}O_3$; Cl = +5

6. (a) $Cr_2O_7^{2-}(aq) + \mathbf{3}\ H_2O_2(aq) + \mathbf{8}\ H^+(aq) \rightarrow \mathbf{2}\ Cr^{3+}(aq) + 3\ O_2(g) + \mathbf{7}\ H_2O(l)$
(b) $\mathbf{2}\ MnO_4^-(aq) + \mathbf{5}\ H_2C_2O_4(aq) + \mathbf{6}\ H^+(aq) \rightarrow \mathbf{2}\ Mn^{2+}(aq) + \mathbf{5}\ CO_2(g) + \mathbf{8}\ H_2O(l)$

7. (a) $\mathbf{2}\ Cr(OH)_4^-(aq) + \mathbf{3}\ H_2O_2(aq) + \mathbf{2}\ OH^-(aq) \rightarrow \mathbf{2}\ CrO_4^{2-}(aq) + \mathbf{8}\ H_2O(l)$;
(b) $\mathbf{2}\ MnO_4^-(aq) + \mathbf{3}\ NO_2^-(aq) + H_2O \rightarrow \mathbf{2}\ MnO_2(s) + \mathbf{3}\ NO_3^-(aq) + \mathbf{2}\ OH^-(aq)$;

8. (a) 0.05010 *M*; (b) 0.1165 *M*;

9. (a) 0.2109 *M*; (b) 4.22 *M*

10. (a) $AgNO_3$ = 0.0375 mol; NaBr = 0.0500 mol; $AgNO_3$ is the limiting reactant;
(b) 7.04 g AgBr; (c) Percent yield = 92.6%;

11. (a) *strong electrolyte* (b) *strong electrolyte* (c) *nonelectrolyte* (d) *weak electrolyte* (e) *strong electrolyte* (f) *weak electrolyte* (g) *strong electrolyte* (h) *strong electrolyte* (*i*) *weak electrolyte* (j) *nonelectrolyte* (k) *strong electrolyte* (*l*) *weak electrolyte*

12. (a) *w* = -41.5 L.atm; -4.20 kJ; work is done by the gas; (b) ΔE = 30.8 kJ;

13. Final temperature of mixture = 44.0°C

14. Mass of cold water = 90.0 g;

15. Specific heat of metal = 0.39 J/g.°C

16. (a) Q_{H2O} = 25.8 kJ; Q_{bomb} = 3.54 kJ; (b) Q_{comb} = -29.3 kJ;
(c) Q_{comb} = –26.4 kJ/g; (d) ΔH_{comb} = -3.23×10^3 kJ/mol

17. (a) ΔH = –1275.8 kJ; (b) 19.9 kJ/g; (c) Q_{H2O} = 313 kJ; (d) 15.7 g of CH_3OH are need;

18. ΔH^o = -23 kJ;

19. ΔH^o = -95.6 kJ

20. (a) *minimum energy* = 3.68×10^{-19} J; (b) $\lambda_o = 5.40 \times 10^2$ nm; (c) $E_{\lambda\ (512\ nm)} = 3.88 \times 10^{-19}$ J, which is higher than the minimum energy needed; electron will be ejected by this photon;
(d) *Kinetic energy* of ejected electron = 2.0×10^{-20} J; speed of ejected electron = 2.1×10^5 m/s)

21. (a) $\Delta E = -4.09 \times 10^{-19}$ J; (b) Electron loses energy; (c) λ = 486 nm

22. (a) K.E. of electron = 2.40×10^{-19} J; (b) velocity of electron, $v_e = 7.26 \times 10^5$ m/s;
(c) de Broglie wavelength, $\lambda_e = 1.00 \times 10^{-9}$ m = 1.00 nm.

23. (a) subshell symbol = 2p; # of orbitals = 3; # of electrons = 6;
(b) subshell symbol = 4f; # of orbitals = 7; # of electrons = 14;
(c) Not allowed; *l* cannot equal *n*;
(d) subshell symbol = 6s; # of orbitals = 1; # of electrons = 2;
(e) subshell symbol = 5d; # of orbitals = 5; # of electrons = 10;

24. (a) Ca: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$
(b) Cl: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$
(c) Cu: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$
(d) Ni: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^8$
(e) Se: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^4$

25. (a) N (Z = 7): [He] ↑↓ (2s) ↑ ↑ ↑ (2p); (paramagnetic)

(b) Si (Z = 14): [Ne] ↑↓ (3s) ↑ ↑ __ (3p); (paramagnetic)

(c) Cr (Z = 24): [Ar] ↑ (4s) ↑ ↑ ↑ ↑ ↑ (3d); (paramagnetic)

(d) Zn (Z = 30): [Ar] ↑↓ (4s) ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ (3d) (diamagnetic)

(e) As (Z = 33): [Ar] ↑↓ (4s) ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ (3d) ↑ ↑ ↑ (4p);

26. (a) Group 3A; 3rd period; (b) Group 1B; 4th period; (c) Group 6A; 4th period;
(d) Group 2A; 5th period; (e) Group 5B; 4th period. (f) Group 4A; 6th period.

27. (a) In the Periodic Table, *atomic size* decreases from left-to-right. *Effective nuclear charge* increases from left to right as the number of protons increases, but valence-shell stays the same. The increasing nuclear attraction on valence-shell electrons causes the atomic size to decrease.

Going down the group, the number and size of electron shells increase, while effective nuclear charge slightly decreases (due to increasing distance of the valence-shell electrons). The increase in size is mainly due to the increasing shells added to the atom.

(b) (*i*) increasing atomic size: Al < Mg < Na < K < Rb;
(*ii*) increasing ionization energy: Rb < K < Na < Al < Mg;
(*iii*) increasing reactivity: Al < Mg < Na < K < Rb.

(c) (*i*) increasing atomic size: F < Cl < Br < I;
(*ii*) increasing electron affinity: I < Br < F < Cl;
(*iii*) increasing reactivity: I < Br < Cl < F.