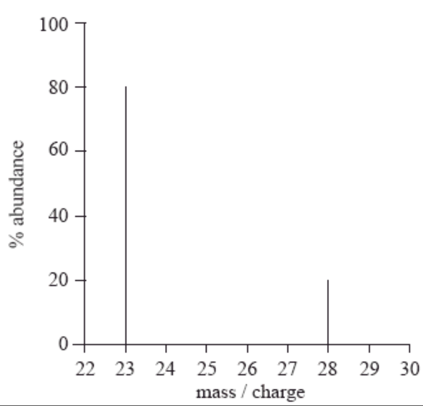
Name ____ Date ____________

IB Chemistry HL-II Summer Review

Unit 1 – Atomic Structure

IB 2.1 The nuclear atom

1. State the number of protons, neutrons, and electrons in each of the following:
   a. ^{65}Cu
   b. $^{15}N^{3-}$
   c. $^{137}Ba^{2+}$
2. Determine the relative atomic mass of copper (to 2 decimal places) given the following natural abundances: ^{63}Cu 76.00% and ^{65}Cu 24.00%
3. Determine the natural abundance of ^{11}B given that boron consists of two isotopes, ^{10}B and ^{11}B, and the relative atomic mass is 10.80.
4. What is the relative atomic mass of an element with the following mass spectrum?



IB 2.2 Electron Configuration

1. The wavelength of a line in the emissions spectrum of hydrogen is 6.56×10^{-7} m.
   a. Calculate the frequency of the light emitted.
   b. Calculate the energy difference.

2. Which change in energy level results in the highest energy transition?
    a. n=4 → n=2
    b. n=12 → n=3
    c. n=2 → n=1
    d. n=15 → n=2

3. Give the full electron configurations of:
    a. B
    b. P
    c. Ti
    d. Cr
    e. Cu
    f. Se

4. Give the condensed (noble gas) configurations of:
    a. Al
    b. As

5. Draw the orbital notation (with arrows) for:
    a. Si
    b. Fe
    c. Cr

6. Give the full electron configurations of:
    a. Na^+
    b. Cl^-
    c. Fe^{3+}

Unit 2 – Periodicity

IB 3.1 Periodic table

1. Identify the property used to arrange the elements in the periodic table.

2. Explain why the noble gases are considered inert (stable).

3. Name or write the formulas of the following ionic and covalent compounds:

Mixed Practice:

Indicate name:

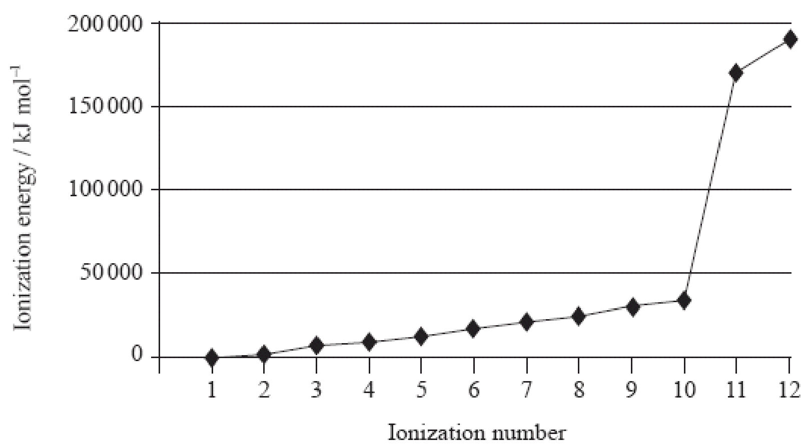
1) MgO
2) P_2O_5
3) $CrCl_2$
4) Ba_3P_2
5) CO
6) Cu_2S
7) GaF_3

Indicate formula:

8) iron (III) oxide
9) dinitrogen tetroxide
10) sodium phosphide
11) manganese (III) nitride
12) magnesium chloride
13) dichlorine heptoxide
14) cobalt (II) oxide

IB 12.1 Electrons in atoms

1. Magnesium is the eighth most abundant element in the earth's crust. The successive ionization energies of the element are shown below.



a. Explain the general increase in successive ionization energies of magnesium.

b. Explain the large increase between the tenth and eleventh ionization energies.

2. The successive ionization energies of germanium are shown in the following table:

	1st	2nd	3rd	4th	5th
Ionization energy / $kJ\ mol^{-1}$	760	1540	3300	4390	8950

Explain the changes in ionization energy from the IE_1 to IE_5. Explain the significant difference between IE_4 and IE_5.

IB 3.2 Periodic trends

1. Which species has the largest radius?

A. P^{-3} B. K C. Na^+ D. K^+

2. Which properties of period 3 elements increase from sodium to argon?

I. Nuclear charge
II. Atomic radius
III. Electronegativity

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

3. When the following species are arranged in order of **increasing** radius, what is the correct order?

A. Cl^-, K, K^+
B. K^+, K , Cl^-
C. Cl^-, K^+, K
D. K, Cl^-, K^+

4. Which statement about electronegativity is correct?

A. Electronegativity decreases across a period.
B. Electronegativity increases down a group.
C. Metals generally have lower electronegativity values than non-metals.
D. Noble gases have the highest electronegativity values.

5. Which statement is correct for a periodic trend?

A. Ionization energy increases from Li to Cs.
B. Melting point increases from Li to Cs.
C. Ionization energy increases from F to I.
D. Melting point increases from F to I.

6. The compounds Na_2O, Al_2O_3 and SO_2 respectively are
   A. acidic, amphoteric and basic.
   B. amphoteric, basic and acidic.
   C. basic, acidic and amphoteric.
   D. basic, amphoteric and acidic.

7. What are the expected products when potassium metal (K) is dropped into water?
   A. H_2 (g) and aqueous K_2O
   B. O_2 (g) and aqueous K_2O
   C. H_2 (g) and aqueous KOH
   D. NO (g) and aqueous KOH

<u>Unit 3 – Stoichiometry</u>

IB 1.2 The mole concept

1. Determine the number of moles in 2.00 g of methane (CH_4).

2. Determine the mass of 0.0100 mol calcium sulfate.

3. Determine the mass of 1 molecule of propan-1-ol (C_3H_7OH)

4. Determine the number of molecules in 1.5 moles of CO_2.

5. Determine the number of oxygen atoms in 0.200 mol HNO_3.

6. Identify the following compounds as empirical or molecular formulas:
   a. C_2H_2
   b. CH_2
   c. N_2H_3
   d. C_3H_5
   e. C_6H_6
   f. NHO

7. A compound contains 24.7% of K, 34.8% of Mn, and 40.5% of O by mass. Determine the empirical formula.

8. A compound has the following composition by mass: 1.665 g C, 0.280 g H, and 0.555 g O. If the relative molecular mass of the compound is 144.24, calculate the molecular formula. (Hint, find empirical first!)

IB 1.3 Reacting masses and volumes

1. Balance the following equations:
    a. $SF_4 + H_2O \rightarrow SO_2 + HF$
    b. $Fe_2O_3 + CO \rightarrow Fe + CO_2$
    c. $NH_3 + O_2 \rightarrow N_2 + H_2O$
2. Calculate the volume of O_2 produced (measured at STP) when 5.00 g of $KClO_3$ decomposes according to the following equation: $2KClO_3\ (s) \rightarrow 2KCl\ (s) + 3O_2\ (g)$
3. What is the limiting reactant when 2.7 mol O_2 reacts with 2.7 mol SO_2? $2SO_2 + O_2 \rightarrow 2SO_3$
4. Calculate the percent yield of $CH_3COOC_2H_5$ given that 10.0 g of C_2H_5OH reacts with excess CH_3COOH to produce 15.0 g of $CH_3COOC_2H_5$.
5. Calculate the concentration of sodium ions in mol dm^{-3} when 1.42 g NaCl is dissolved in water and made up to a total volume of 50.0 cm^3.

Unit 4 – Bonding

IB 4.5 Metallic Bonding

1. Which is a correct description of metallic bonding?
   A. Positively charged metal ions are attracted to negatively charged ions.
   B. Negatively charged metal ions are attracted to positively charged metal ions.
   C. Positively charged metal ions are attracted to delocalized electrons.
   D. Negatively charged metal ions are attracted to delocalized electrons.

2. Explain how alloying can modify the structure and properties of metals.

IB 4.1 Ionic Bonding

1. Which is the best description of ionic bonding?
   A. The electrostatic attraction between positively charged nuclei and an electron pair
   B. The electrostatic attraction between positive ions and delocalized negative ions
   C. The electrostatic attraction between positive ions and delocalized electrons
   D. The electrostatic attraction between oppositely charged ions

IB 4.2-3 Covalent Bonding

1. Draw Lewis structures for these compounds AND determine if they are polar or nonpolar compounds.

NH_3	PCl_3	N_2
C_2H_4	CO_2	HCN

2. Draw resonance structures for:

O_3
C_6H_6
NO_3^-

3. Use formal charges to determine the preferred Lewis structure for XeO_4.

IB 14.1-14.2

1. Predict the shapes and bond angles of:

PCl_5	SO_4^{2-}
SF_6	XeF_2

2. Predict the hybridization present on the central atom:

CH_4	BF_3
H_2O	C_2H_4

3. Determine the number of σ and π bonds in the following:

C_2H_4	HCN	C_2H_2

Unit 5 – Energetics

IB 5.1 Measuring Enthalpy Changes

1. Calculate the enthalpy change of combustion (in kJ mol^{-1}) of hexane (C_6H_{14}) given that, when 1.20 g of hexane is burnt, the temperature of 250.0 g of water is raised by 56.0 ^{o}C.

2. Calculate the enthalpy change of solution (in kJ mol^{-1}) of lithium bromide when 4.50 g of LiBr was dissolved in 125 cm^3 water and the temperature increased by 3.82 °C.

IB 5.2 Hess's Law

1. Using the equations below

$$Cu(s) + \tfrac{1}{2} O_2(g) \rightarrow CuO(s) \Delta H^{\ominus} = -156 \text{ kJ}$$

$$2Cu(s) + \tfrac{1}{2} O_2(g) \rightarrow Cu_2O(s) \Delta H^{\ominus} = -170 \text{ kJ}$$

what is the value of $\Delta H^{\ominus}$ (in kJ) for the following reaction?

$$2CuO(s) \rightarrow Cu_2O(s) + \tfrac{1}{2} O_2(g)$$

2. Calculate the enthalpy change, ΔH_4 for the reaction $C + 2H_2 + \tfrac{1}{2} O_2 \rightarrow CH_3OH \quad \Delta H_4$ using Hess's Law and the following information.

$$CH_3OH + 1\tfrac{1}{2} O_2 \rightarrow CO_2 + 2H_2O \qquad \Delta H_1 = -676 \text{ kJ mol}^{-1}$$

$$C + O_2 \rightarrow CO_2 \qquad \Delta H_2 = -394 \text{ kJ mol}^{-1}$$

$$H_2 + \tfrac{1}{2} O_2 \rightarrow H_2O \qquad \Delta H_3 = -242 \text{ kJ mol}^{-1}$$

3. Consider the following information.

$$C_6H_6(l) + 7\tfrac{1}{2} O_2(g) \rightarrow 6CO_2(g) + H_2O(l)$$

Compound	$C_6H_6(l)$	$CO_2(g)$	$H_2O(l)$
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	+49	+394	–286

What is the correct value of the standard enthalpy change of reaction for benzene (l), in kJ mol^{-1}?

IB 5.3 Bond Enthalpies

1. Use the average bond enthalpies below to calculate the enthalpy change, in kJ, for the following reaction.

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

Bond	Bond energy / kJ mol^{-1}
H–H	440
I–I	150
H–I	300

2. Use the average bond enthalpies below to calculate the enthalpy change, in kJ, for the following reaction.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

Bond	Bond energy / kJ mol^{-1}
N≡N	945
H–H	436
N–H	388

IB 15.2 Entropy and Spontaneity

1. State whether each of the reactions below involves an increase or decrease in entropy.
   a. $NH_4Cl(s) \rightarrow NH_3(g) + HCl\ (g)$
   b. $C_2H_5OH\ (g) + 3O_2\ (g) \rightarrow 2CO_2\ (g) + 3H_2O\ (l)$

2. The reaction between but-1-ene and water vapour produces butan-1-ol: $C_4H_8(g) + H_2O(g) \rightarrow C_4H_9OH(l)$
   The standard entropy values ($S^{\ominus}$) for but-1-ene, water vapour and butan-1-ol are 310, 189 and 228 J K^{-1} mol^{-1} respectively. What is the standard entropy change for this reaction in J K^{-1} mol^{-1}?

3. Given that $\Delta H = -2220$ kJ mol^{-1} and $\Delta S = -370$ J mol^{-1} K^{-1}, calculate ΔG for the following reaction and state whether it is spontaneous or not at 298 K. $C_3H_8(g) + 5O_2\ (g) \rightarrow 3CO_2\ (g) + 4\ H_2O(l)$

Unit 6 – Equilibrium

IB 7.1 The Equilibrium Constant

1. Write expressions for the equilibrium constant, K_c, for each of the following:
   a. $CH_4 (g) + 2H_2O (g) \rightleftharpoons CO_2(g) + 4H_2(g)$

   b. $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

2. The equilibrium constant for the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ is K_c. The equilibrium constant for the reaction $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$ is K_c\`. The relationship between $K_c$ and $K_c$\` is ___.

3. Predict the effect of the changes listed on the position of equilibrium for
   $CH_4 (g) + H_2O (g) \rightleftharpoons CO(g) + 3H_2(g)$ $\Delta H = +206$ kJ mol^{-1}
   a. Increasing the pressure
   b. Decreasing the temperature
   c. Adding hydrogen
   d. Adding a catalyst

IB 17.1 The Equilibrium Law

1. 2.00 mol A and 1.00 mol B are mixed together in a vessel of volume 2.00 dm^3 and allowed to come to equilibrium at 500 K. At equilibrium there were 1.60 mol of A present in the reaction mixture. Calculate the value of K_c at 500 K. $A(g) + 2B (g) \rightleftharpoons 2C(g)$

2. Consider the reaction $A(g) + B (g) \rightleftharpoons 2C(g)$. 1.00 mol A and 1.00 mol B are put into a 1.00 dm^3 volume container and allowed to come to equilibrium at 600 K. Given that the value of K_c at 600 K is 0.25, determine the concentration of each component at equilibrium.