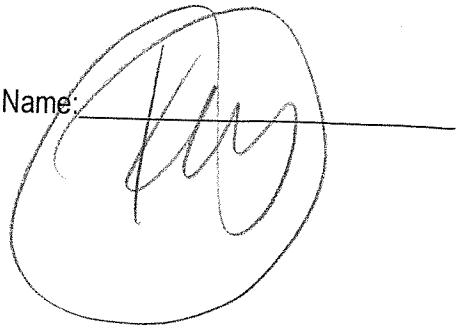
Name: 

IB Chemistry Semester I Exam Topic Review

Topic 1- Stoichiometric Relationships

1.1 Introduction to the particulate nature of matter and chemical change
types of chemical equations, balancing chemical equations

1.2 The mole concept
avogadro's number/molar mass calculations/conversions, empirical and molecular formula

1.3 Reacting masses and volumes
limiting and excess reactants, experimental and theoretical yield, molar concentration and solution preparation, standard solutions and titration reactions

11.1 Uncertainties and errors in measurement and results
qualitative v. quantitative data, random v. systematic errors, error propagation

Topic 2- Atomic Structure

2.1 The nuclear atom
protons, neutrons, electrons, mass spec problems

2.2 Electron configuration
electron configuration/orbital notation and exceptions, emission/absorption spectra

12.1 Electrons in atoms
ionization energy (removing from different sublevels)

Topic 3- Periodicity

3.1 The Periodic Table
identify different parts, groups, periods

3.2 Periodic Trends
ionization energy, atomic radius, ionic radius, electronegativity, acidity, electron affinity

Topic 4- Chemical Bonding and Structure

4.1 Ionic Bonding and Structure
naming ions/ionic compounds and recognizing ionic bonding, physical properties

4.2 Covalent Bonding
formation of covalent bonds (single, double, triple), bond length v. bond strength, polarity of bonds

4.3 Covalent Structures
Lewis structures, coordinate covalent/dative bonds, VSEPR theory, bond angles, polarity of molecules, resonance structures

4.4 Intermolecular Forces
London dispersion forces, dipole-dipole forces, hydrogen bonding, physical properties

4.5 Metallic Bonding
formation, strength, alloys

14.1 Further aspects of covalent bonding and structure
expanded octet, molecular geometry, sigma and pi bonds, formal charge, O_3

14.2 Hybridization
sp, sp2, sp3 identification

Name:_____

There are three isotopes of Silicon, ^{28}Si, ^{29}Si, and ^{30}S. The percent abundance ^{30}Si is 3.09%. Using this information and the periodic table, calculate the percent abundance of ^{28}S and ^{29}S, and sketch the mass spectra you would expect. Show your work.

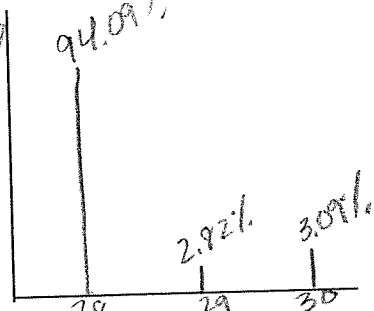
		%
^{28}Si	x	94.09%
^{29}Si	$.9691-x$	2.82%
^{30}Si	$.0309$	3.09%

$28.09=(28x)+(29)(.9691-x)+(30)(.0309)$

$28.09=28x+28.1039-29x+0.927$

$28.09=29.0309-x$

$-.9409=-x$



A student measures a rectangle to have one side of length 3.2 ± 0.2 cm and measures the other side to have a length of 0.045 ± 0.002 meters. Calculate the area of the rectangle and include error.

$A=lw=(3.2)(0.045)=0.144$

$.144\pm0.0154\ cm^2$

(error: $\frac{0.2}{3.2}$) (error: $\frac{0.002}{0.045}$) $=0.10694\times.144=0.0154$

A 0.64 ± 0.01g piece of Magnesium Metal is burned in oxygen gas. Calculate the number of moles Mg that were reacted, include error.

$0.64g\left|\frac{1mol}{24.3g}\right.=0.026$ error: $\frac{0.01}{0.64}=.015625\times0.026$

$=.0004115$

$0.02634\pm.0004$

A 2.85 ± 0.05 cm piece of Mg is used to react in the previous question. Calculate the percent uncertainty from the given ~~fractional~~ absolute uncertainty.

$\left(\frac{0.05}{2.85}\right)\times100$ 1.75%

$n=Mv=(.6)(.03)=.018$ $n=Mv=(0.2)(.0100)=.002mol$

12 What is the concentration of NaCl, in mol dm^{-3}, when 10.0 cm^3 of 0.200 mol dm^{-3} NaCl solution is added to 30.0 cm^3 of 0.600 mol dm^{-3} NaCl solution?

$M=\frac{n}{V}=\frac{0.02}{0.04}$

A 0.450 **B** 0.300 **C** 0.500 **D** 0.800

$n=MV=(.35)(.05)=0.0175\ mol$ $n=Mv=(.150)(.125)=.0185$

50.0 cm^3 of a 0.350 mol*dm^{-3} solution of potassium chloride is added to 150. cm^3 of 0.125 mol*dm^{-3} aqueous lead (II) nitrate. Write a balanced molecular equation, full ionic, and net ionic equation for the reaction, determine which reactant limits, and how much solid could theoretically be produced.

$2KCl_{(aq)}+Pb(NO_3)_{2(aq)}\rightarrow2KNO_{3(aq)}+PbCl_{2(s)}$

$2K^{+1}_{(aq)}+2Cl^-_{(aq)}+Pb^{2+}_{(aq)}+2NO_{3(aq)}^-\rightarrow2K^+_{(aq)}+2NO_{3(aq)}^-+PbCl_{2(s)}$

$Pb^{2+}_{(aq)}+2Cl^-_{(aq)}\rightarrow PbCl_{2(s)}$

LR

$.0175mol\ KCl\left|\frac{1}{2}\right|\frac{278.1g}{1mol}=2.43g\ PbCl_2$

$.0185\ mol\ Pb(NO_3)_2\left|\frac{1}{1}\right|\frac{278.1g}{1}=5.144g\ PbCl_2$

Name:_____

IB Chemistry Semester I Exam Topic Review – Practice Questions

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Paper 1- 40 Multiple Choice Questions
Periodic Table only (no calculator, no data booklet)
Topic 1

1. What is the empirical formula of a compound containing 50% by mass of element X (A_r = 20) and 50% by mass of element Y (A_r = 25)? 50/25 50/20

   D
   A. XY
   B. X_3Y_2
   C. X_4Y_5
   (D.) X_5Y_4

   X: (2.5) x 2 Y: (2) x 2
   X: 5 Y: 4

2. The empirical formula of a compound is C_2H_4O. Which molecular formulas are possible for this compound?

   ~~I. CH_3COOH~~
   II. $CH_3CH_2CH_2COOH$ ✓ (ratio: 2)
   III. $CH_3COOCH_2CH_3$ ✓ (ratio: 2)

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

3. What amount (in moles) is present in 2.0 g of sodium hydroxide, NaOH?

   A
   (A.) 0.050
   B. 0.10
   C. 20
   D. 80

   $\frac{2.0\,g \mid 1\,mol}{(23+16+1)\,g} = 0.05$

4. How many hydrogen atoms are contained in one mole of ethanol, C_2H_5OH?

   D
   A. 5
   B. 6
   C. 1.0×10^{23}
   (D.) 3.6×10^{24}

   1 mol ethanol : 6 mol H

   $\frac{6\,mol\,H \mid 6.02\times10^{23}\,atoms}{1\,mol} =$

5. Air bags in cars inflate when sodium azide decomposes to form sodium and nitrogen:
   $2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$
   Calculate the amount, in moles, of nitrogen gas produced by the decomposition of 2.52 mol of $NaN_3(s)$.

   C
   A. 1.68
   B. 2.52
   (C.) 3.78
   D. 7.56

   $\frac{2.52\,mol\,NaN_3 \mid 3N_2}{2\,mol\,NaN_3} = 3.78\,mol$

Name:_____

6. Lithium hydroxide reacts with carbon dioxide as follows.

$$2LiOH + CO_2 \rightarrow Li_2CO_3 + H_2O$$

What mass (in grams) of lithium hydroxide is needed to react with 11 g of carbon dioxide?

A. 6
B. 12
C. 24
D. 48

B

$$\frac{11\,g\,CO_2}{44\,g\,CO_2}\left|\frac{1\,mol\,CO_2}{1\,mol\,CO_2}\right|\frac{2\,mol\,LiOH}{1\,mol\,LiOH}\left|\frac{23.95\,g\,LiOH}{1\,mol\,LiOH}\right. = 11.97$$

7. Which sample has the greatest mass?

A. 1 mol of SO_2 ≈ 64
B. 2 mol of N_2O ≈ 88
C. 2 mol of Ar ≈ 80
D. 4 mol of NH_3 ≈ 68

B

8. What is the total number of hydrogen atoms in 1.0 mol of benzamide, $C_6H_5CONH_2$?

A. 7
B. 6.0×10^{23}
C. 3.0×10^{24}
D. 4.2×10^{24}

D

1 mol benzamide : 7 mol H

$$\frac{7\,mol\,H}{1\,mol}\left|\frac{6.02\times10^{23}\,atoms}{}\right.$$

9. Which is both an empirical and a molecular formula?

A. C_5H_{12}
B. C_5H_{10} reducible
C. C_4H_8 "
D. C_4H_{10} "

A

10. The molar mass of a compound is approximately 56 g mol^{-1}. Which formula is possible for this compound?

A. $NaNO_3$ ≈ 85
B. AgOH ≈ >107
C. MgO ≈ 39
D. KOH ≈ 59

D

11. Which sample has the greatest mass?

A. 6.0×10^{25} molecules of hydrogen ÷ 6.02×10^{23} × 1.01 g
B. 5.0 mol of neon atoms ÷ 6.02×10^{23} × 20.18 g
C. 1.2×10^{24} atoms of silver ÷ 6.02×10^{23} × 107.87
D. 1.7×10^{2} g of iron

C

12. On analysis, a compound with molar mass 60 g mol^{-1} was found to contain 12 g of carbon, 2 g of hydrogen and 16 g of oxygen. What is the molecular formula of the compound?

A. CH_2O
B. CH_4O
C. C_2H_4O
D. $C_2H_4O_2$

D

1 : 2 : 1

emp.: CH_2O

60/30 = 2 × CH_2O

13. Equal masses of the metals Na, Mg, Ca and Ag are added to separate samples of excess HCl(aq). Which metal produces the greatest total volume of H_2(g)?

A. Na
B. Mg
C. Ca
D. Ag

B

$2Na + 2HCl \rightarrow 2NaCl + H_2$ → $\frac{10g}{23g}\left|\frac{1\,mol}{2}\right|\frac{1}{1}\left|\frac{22.4}{}\right.$

$Mg + 2HCl \rightarrow MgCl_2 + H_2$ → $\frac{10g}{24}\left|\frac{1\,mol}{1}\right|\frac{1}{1}\left|\frac{22.4}{}\right.$

$Ca + 2HCl \rightarrow CaCl_2 + H_2$ → $\frac{10g}{40}\left|\frac{1\,mol}{1}\right|\frac{1}{1}$

$2Ag + 2HCl \rightarrow 2AgCl + H_2$

Name:_____

14. Which one of the following statements about SO_2 is/are correct?

I. One mole of SO_2 contains 1.8×10^{24} atoms $(6.02\times10^{23}) \times 3 = 1.8\times10^{24}$ ✓

II. One mole of SO_2 has a mass of 64g ✓

A. Both I and II

B. Neither I nor II

C. I only

D. II only

A

15. A pure compound contains 24g of carbon, 4 g of hydrogen, and 32 g of oxygen. No other elements are present. What is the empirical formula of the compound? 2/2 4/2 2/2

A. $C_2H_4O_2$

B. CH_2O 1 : 2 : 1

C. CH_4O

D. CHO

B

16. What is the empirical formula for the compound $C_6H_5(OH)_2$?

A. C_6H_6O

B. $C_6H_5O_2H_2$

C. C_6H_7O

D. $C_6H_7O_2$

D

Topic 2- Atomic Structure

2.1 The nuclear atom

protons, neutrons, electrons, mass spec problems

2.2 Electron configuration

electron configuration/orbital notation and exceptions, emission/absorption spectra

12.1 Electrons in atoms

ionization energy (removing from different sublevels)

17. Which statement about the numbers of protons, electrons and neutrons in an atom is always correct?

A. The number of neutrons minus the number of electrons is zero.

B. The number of protons plus the number of neutrons equals the number of electrons.

C. The number of protons equals the number of electrons.

D. The number of neutrons equals the number of protons.

C

18. Which statements about the isotopes of chlorine, ^{35}Cl and ^{37}Cl, are correct?

I. They have the same chemical properties. ✓

II. They have the same atomic number. ✓

III. They have the same physical properties. → mass / density / MP / BP are different

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

A

19. Which statement about the isotopes of an element is correct?

A. They have the same mass number.

B. They have a different atomic number.

C. They have the same chemical properties. → same valence e^-

D. They are located in different places in the periodic table.

C

Name:_____

Atomic #

20. What is the atomic number of a neutral atom, which has 51 neutrons and 40 electrons?
    A. 40
    B. 51
    C. 91
    D. 131

21. Which is the correct definition of the mass number of an atom?
    A. The total mass of neutrons and protons in the nucleus of the atom
    B. The total mass of neutrons, protons and electrons in the atom
    C. The number of protons in the nucleus of the atom
    D. The total number of neutrons and protons in the nucleus of the atom

22. Which species have the same number of electrons?
    I. S^{2-} 18
    II. Cl^- 18
    III. Ne 10
    A. I and II only
    B. I and III only
    C. II and III only
    D. I, II and III

23. How many protons, neutrons and electrons are present in each atom of ^{31}P? 15

	Protons	Neutrons	Electrons
A.	16	15	16
B.	15	16	15
C.	15	31	15
D.	16	31	16

24. How many valence electrons are present in an atom of an element with atomic number 16?
    A. 2
    B. 4
    C. 6
    D. 8

Sulfur (group 16)

25. What is the total number of electrons in p orbitals in an atom of iodine?
    A. 5
    B. 7
    C. 17
    D. 23

3 orbitals per p × 2e⁻ = 6e⁻ × 3 full = 18e⁻
+ 5e⁻ = 23e⁻

26. What is the electron configuration for the copper(II) ion (Z = 29)?
    A. $[Ar]4s^2 3d^9$
    B. $[Ar]4s^1 3d^{10}$
    C. $[Ar]4s^1 3d^9$
    D. $[Ar]3d^{10}$

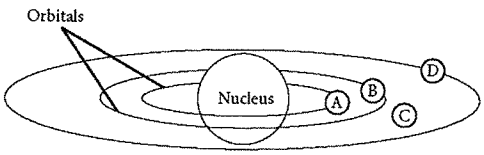
oops – if atom exception.

27. Which electron transition in a hydrogen atom would release light in the visible spectrum?
    A. n = 2 → n = 1
    B. n = 5 → n = 2
    C. n = 2 → n = 3
    D. n = 7 → n = 1

Name:_____

28. According to Bohr, electrons cannot reside at _____ in the figure below.

A. point A
B. point B
C. point C
D. point D



29. When the pink-colored light of glowing hydrogen gas passes through a prism, it is possible to see:

A. all the colors of the rainbow.
B. only lavender-colored lines.
C. four lines of different colors.
D. black light.

30. Because most particles fired at gold foil passed straight through, Rutherford concluded that:

A. atoms were mostly empty space.
B. atoms contained no charged particles.
C. electrons formed the nucleus.
D. atoms were indivisible.

31. It was very unexpected that some of the alpha particles in Rutherford's gold fold experiment were repelled by some unknown force and bounced back. This led Rutherford to the discovery of the:

A. proton.
B. nucleus.
C. neutron.
D. electron.

32. Experiments with cathode rays by JJ Thomson led to the discovery of the _____ and the development of the "plum pudding model."

A. proton.
B. nucleus.
C. neutron.
D. electron.

Topic 3- Periodicity

3.1 The Periodic Table

identify different parts, groups, periods

3.2 Periodic Trends

ionization energy, atomic radius, ionic radius, electronegativity, acidity, electron affinity

33. An element is in group 3 and period 4 of the periodic table. How many electrons are in the highest occupied energy level of an atom of this element?

A. 3
B. 4
C. 12
D. 14

34. In the Periodic Table, elements are arranged in order is increasing

A. atomic mass
B. atomic number
C. number of valence electrons
D. electronegativity

35. In which region of the periodic table would the element with the electron configuration below be located?
$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^6 5s^2$

A. group 6
B. noble gases
C. s block
D. d block

Name:_____

36. Which property generally decreases across Period 3?
A. Atomic Number
B. Electronegativity
C. Atomic Radius
D. First Ionization Energy

37. Strontium is an element in Group 2 of the Periodic Table with atomic number 38. Which of the following statements about Strontium is NOT correct?
A. Its first ionization energy is lower than that of Calcium.
B. It has two electrons in its outermost energy level.
C. Its atomic radius is smaller than Magnesium.
D. It forms a chloride with the formula $SrCl_2$.

38. Which of the following elements has the lowest first ionization energy?
A. Li
B. Na
C. Mg
D. Al

39. All of the following factors affect the value of the ionization energy of an atom except the
A. Mass of the atom
B. Charge on the nucleus
C. Size of the atom
D. Main energy level from which the electron is removed

40. Which property decreases down Group 17 in the Periodic Table?
A. Melting Point
B. Electronegativity
C. Atomic Radius
D. Ionic Radius

41. Which is the best definition of electronegativity?
A. Electronegativity is the energy required for a gaseous atom to gain an electron.
B. Electronegativity is a measure of the ability of an atom to attract electrons in a covalent bond.
C. Electronegativity is the attraction between the nucleus and the valence electrons of an atom.
D. Electronegativity is a measure of the ability of an atom to steal electrons from another atom.

42. The first four ionization energies (kJ mol^{-1}) for a particular element are 550, 1064, 4210, and 5500, respectively. This element should be placed in the same Group as
A. Li
B. Be
C. B
D. C

43. Which property increases down group 1?
A. First ionization energy
B. Melting point
C. Reactivity
D. Electronegativity

44. Which property increases with increasing atomic number for both the alkali metals and the halogens?
A. First ionization energy
B. Melting point
C. Atomic Radii
D. Electronegativity

Name:_____

45. Which ion has the largest radius?

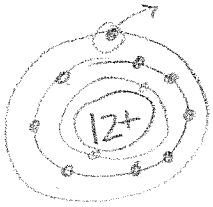
A. Cl^-
B. K^+
C. Br^-
D. F^-

46. Which equation best represents the first ionization energy of magnesium?

A. $Mg(g) \rightarrow Mg^+(g) + e^-$
B. $Mg(g) + e^- \rightarrow Mg^-(g)$
C. $Mg(s) \rightarrow Mg^+(s) + e^-$
D. $Mg(g) \rightarrow Mg^{2+}(g) + 2e^-$

47. Which ionization requires the most energy?

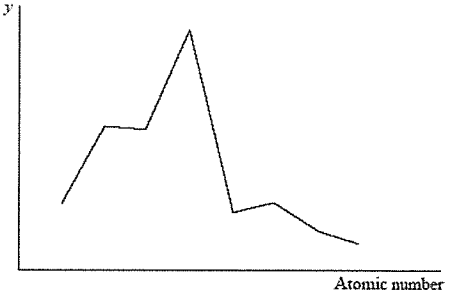
A. $Na(g) \rightarrow Na^+(g) + e^-$
B. $Na^+(g) \rightarrow Na^{2+}(g) + e^-$
C. $Mg(g) \rightarrow Mg^+(g) + e^-$
D. $Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$



48. The x-axis of the graph below represents the atomic number of the elements in period 3.

Which variable could represent the y-axis?

A. Melting point
B. Electronegativity
C. Ionic radius
D. Atomic radius



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sp, sp2, sp3 identification

49. Which is the best description of the bonding present in the ammonium ion, NH_4^+?

A. Sharing of electrons between atoms
B. Electrostatic attraction between ions
C. Electrostatic attraction between positive ions and delocalized electrons
D. Sharing of electrons between atoms and electrostatic attraction between ions

Name:_____

50. How do the bond angles in CH_4, NH_3 and H_2O compare?

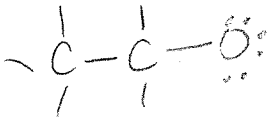
D

A. $CH_4 = NH_3 = H_2O$
B. $CH_4 < NH_3 < H_2O$
C. $NH_3 < CH_4 < H_2O$
D. $H_2O < NH_3 < CH_4$

51. Which species does not contain delocalized electrons?

A

A. $CH_3CH_2O^-$
B. $CH_3CO_2^-$
C. O_3
D. NO_3^-

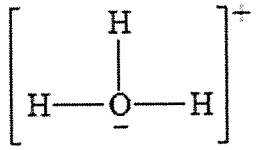


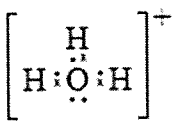
52. Which molecule has a non-bonding (lone) pair of electrons on the central atom?

B

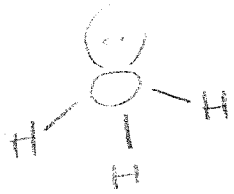
A. BF_3
B. SO_2
C. CO_2
D. SiF_4

53. Lewis structures are represented in different ways in different parts of the world. Two ways of drawing the Lewis structure for H_3O^+ are shown below.





Which statement is correct about H_3O^+?

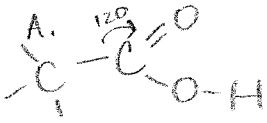


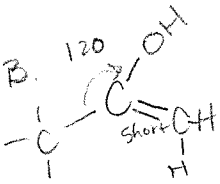
A. The ion has a tetrahedral shape.
B. The H–O–H bond angle is 120°.
C. The H–O–H bond angle is 90°.
D. The ion has a trigonal pyramidal shape.

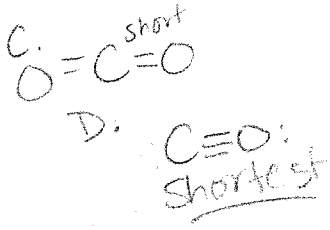
54. Which molecule has the shortest carbon-oxygen bond length?

D

A. CH_3COOH
B. CH_3CH_2OH
C. CO_2
D. CO







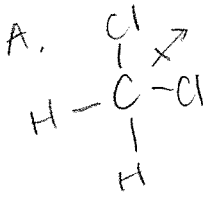
~~55. Which statement about the bonding between carbon atoms is correct?~~

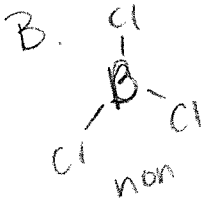
~~A. In C_{60} fullerene each carbon atom is covalently bonded to three other carbon atoms.~~
~~B. In C_{60} fullerene each carbon atom is covalently bonded to four other carbon atoms.~~
~~C. In graphite each carbon atom is covalently bonded to four other carbon atoms.~~
~~D. In graphite each carbon atom forms a double covalent bond with three other carbon atoms.~~

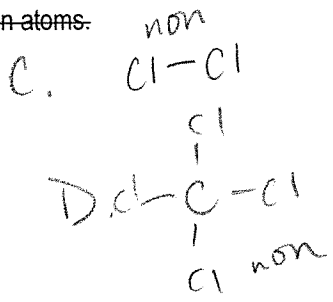
56. Which molecule is polar?

A

A. CH_2Cl_2
B. BCl_3
C. Cl_2
D. CCl_4







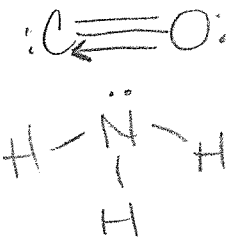
Name:_____

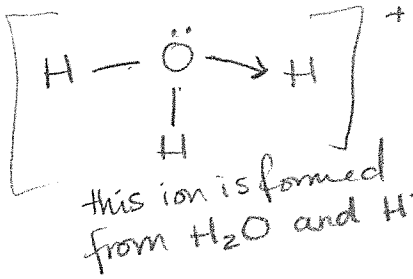
57. Which compound has a covalent macromolecular (giant covalent) structure?

A. $MgO(s)$ ionic
B. $Al_2O_3(s)$ ionic
C. $P_4O_{10}(s)$ simple covalent
D. $SiO_2(s)$ giant

58. Which species have a dative covalent bond?

I. CO → coordinate
II. NH_3
III. H_3O^+





this ion is formed from H_2O and H^+

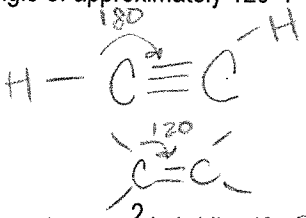
A. I and II only
B. I and III only
C. II and III only
D. I, II and III

59. The Lewis structure of XeF_2 contains two bonding pairs of electrons and three non-bonding pairs of electrons (lone pairs) around the central xenon atom. What is the shape of XeF_2 molecule?

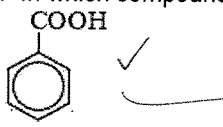
A. Bent
B. Trigonal bipyramidal
C. Square planar
D. Linear

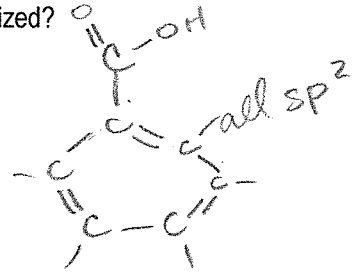
60. Which molecule contains a bond angle of approximately 120°?

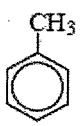
A. CH_4 109.5
B. C_2H_2 180
C. C_2H_4 120
D. C_2H_6 109.5



61. In which compound are all the carbon atoms sp^2 hybridized?

A. 



B. 

same, except sp^3

C. CH_2CHCH_3 sp^3

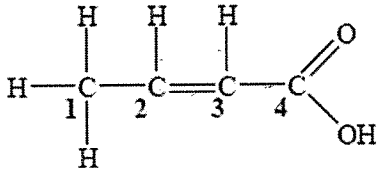
D. $CH_3CH_2CHCHCH_2CH_3$ sp^2

62. In which substance does a carbon atom have sp^2 hybridization?

A. 2-methylbutan-1-ol
B. Propyne, CH_3CCH
C. C_{60} fullerene
D. Diamond

Name:_____

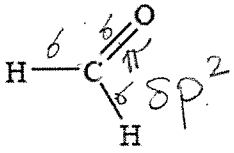
63. Identify the hybridization of carbon atoms in this molecule



	1	2	3	4
A.	sp^3	sp^2	sp^2	sp^2
B.	sp^2	sp^2	sp^2	sp
C.	sp^3	sp	sp^2	sp
D.	sp	sp^2	sp	sp^2

A

64. What is the hybridization of the carbon atom, and the number of σ and π bonds in the methanal molecule?



A

	Hybridization	σ bonds	π bonds
A.	sp^2	3	1
B.	sp^3	3	1
C.	sp^3	4	0
D.	sp^2	4	0

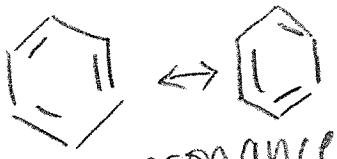
65. When the substances below are arranged in order of increasing carbon-carbon bond length (shortest bond first) what is the correct order?

I. H2CCH2
II. H3CCH3
III.  (benzene)

I. C=C short

I. C-C long

III



resonance (intermediate)

A. I < II < III
B. I < III < II
C. II < I < III
D. III < II < I

B

Name:_____

Paper 2- Free Response Format
(Data booklet and calculator allowed)

100.g of solid aluminium hydroxide is mixed with 100.g mol of aqueous sulfuric acid, and the following reaction occurs to form aqueous aluminum sulfate and liquid water.

(a) Write a balanced chemical equation with state symbols for the reaction.

$2Al(OH)_{3(s)} + 3H_2SO_{4(aq)} \rightarrow Al_2(SO_4)_{3(aq)} + 6H_2O_{(l)}$

(2)

(b) Determine the limiting reactant.

$100g\ Al(OH)_3 \left| \frac{1\ mol}{78g} \right| \frac{3\ mol\ H_2SO_4}{2\ mol\ Al(OH)_3} \left| \frac{98g}{1\ mol} \right. = 188g\ H_2SO_4\ needed$

$100g\ H_2SO_4 \left| \frac{1\ mol}{98g} \right| \frac{2}{3} \left| \frac{78}{1\ mol} \right. = 53g\ Al(OH)_3\ needed$

H_2SO_4 is limiting reagent

(2)

(c) Calculate the mass of aluminium sulfate produced.

$100g\ H_2SO_4 \left| \frac{1\ mol}{98g} \right| \frac{1\ mol}{3\ mol} \left| \frac{342}{1\ mol} \right. = 116g\ Al_2(SO_4)_3\ produced$

(2)

(d) Determine the amount (in mol) of excess reactant that remains.

$100g - 53g = 47g \left| \frac{1\ mol}{78g} \right. = 0.603\ mol\ Al(OH)_3\ excess$

(1)

Aspirin, $C_9H_8O_4$, is made by reacting ethanoic anhydride, $C_4H_6O_3$ (Molar Mass = M_r = 102.1), with 2-hydroxybenzoic acid (M_r = 138.1), according to the equation:

2-hydro EthAn Aspirin

$2C_7H_6O_3 + C_4H_6O_3 \rightarrow 2C_9H_8O_4 + H_2O$

a. If 15.0g 2-hydroxybenzoic acid is reacted with 15.0g ethanoic anhydride, determine the limiting reagent in this reaction.

$15g\ 2\text{-hydro} \left| \frac{1\ mol}{138g} \right| \frac{1\ mol}{2\ mol} \left| \frac{102g}{1\ mol} \right. = 5.54g\ EthAn\ needed$

$15g\ EthAn \left| \frac{1\ mol}{102} \right| \frac{2\ mol}{1\ mol} \left| \frac{138}{1\ mol} \right. = 40.6g\ 2\text{-hydro needed}$

2-hydrobenzoic acid LR

Name:_____

b. Calculate the maximum mass of aspirin that could be obtained in this reaction.

$15\text{g}\ 2\text{-hydroxybenzoic acid} \times \frac{1\text{mol}}{138\text{g}} \times \frac{2\text{mol}}{1\text{mol}} \times \frac{180\text{g}}{1\text{mol}} = 19.6\text{g Aspirin}$

c. If the mass obtained in this experiment was 13.8g, calculate the percent yield of aspirin.

$\frac{13.8}{19.6} \times 100$

70.4%

Determine the empirical and molecular formulas of each of the following substances:

1. Caffeine, a stimulant found in coffee, contains 49.5% C, 5.15% H, 28.9% N, and 16.5% O by mass and has a molar mass of 195 g/mol.

Emp

C	49.5/12 = 4 mol
H	5.15/1.01 = 5 mol
N	28.9/14 = 2 mol
O	16.5/16 = 1 mol

$C_4H_5N_2O$

molar mass = 97 g/mol

Molecular

$\frac{195}{97} \approx 2 \times (C_4H_5N_2O)$

$= C_8H_{10}N_4O_2$

2. Monosodium glutamate (MSG), a flavor enhancer in certain foods, contains 35.51% C, 4.77% H, 37.85% O, 8.29% N, and 13.60% Na, and has a molar mass of 169 g/mol.

Emp

C	35.51/12 = 2.96/0.59 = 5
H	4.77/1 = 4.72/0.59 = 8
O	37.85/16 = 2.36/0.59 = 4
N	8.29/14 = 0.59/0.59 = 1
Na	13.60/23 = 0.59/0.59 = 1

$C_5H_8O_4NaN$

Molar mass = 169 g/mol

Molecular

$169/169 = 1$

Emp = Molecular

3. Cadaverine, a foul-smelling substance produced by the action of bacteria on meat, contains 58.55% C, 13.81% H, and 27.40% N by mass; its molar mass is 102.2 g/mol.

Emp

C	58.55/12 = 4.87/1.95 = 2.5 × 2 = 5
H	13.81/1.01 = 13.67/1.95 = 7 × 2 = 14
N	27.40/14 = 1.95/1.95 = 1 × 2 = 2

$C_5H_{14}N_2$

molar mass = 102 g/mol

Molecular

$102/102 = 1$

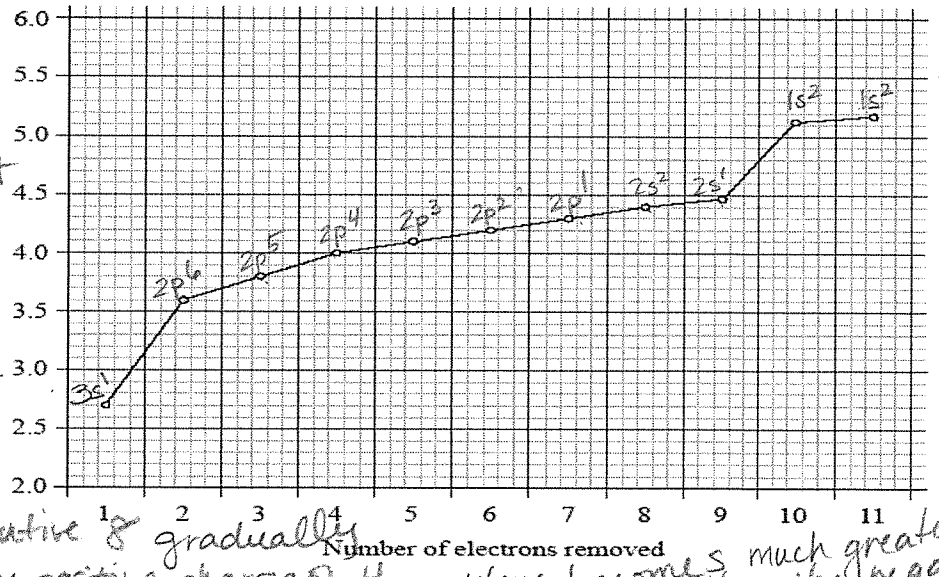
Emp = molecular

Name:_____

4. Draw and label an energy level diagram for the hydrogen atom. In your diagram show how the series of lines in the ultraviolet and visible regions of its emission spectrum are produced, clearly labelling each series.

X

5. The graph below represents the successive ionization energies of sodium. The vertical axis plots log (ionization energy) instead of ionization energy to allow the data to be represented without using an unreasonably long vertical axis.
State the full electron configuration of sodium and explain how the successive ionization energy data for sodium are related to its electron configuration.



$1s^2 2s^2 2p^6 3s^1$

First electron in outermost shell (3s') is furthest from nucleus and held the least tightly due to the distance from nucleus, causing the attraction to be weaker. The next 8 inner electrons are on an energy level closer to the nucleus & more tightly held and have higher IE.

The IE of these next consecutive & gradually increases as the positive charge of the nucleus becomes much greater than the negative charge of the electrons. Finally, the last and closest two e⁻ are held very tightly by the very positive nucleus and require the most IE to remove. (2)

6. (i) State the meaning of the term *electronegativity* and explain why the noble gases are not assigned electronegativity values.

Ability to attract e⁻ in a covalent bond

Noble gases have a full valence shell and do not engage in bonding.

(2)

(ii) State and explain the trend in electronegativity across period 3 from Na to Cl.

EN increases due to ↑ Effective nuclear charge, because in the same period, electrons are added left to right to the same energy level while the charge of the nucleus increases, and the electrons in a bond are pulled closer.

(iii) Explain why Cl_2 rather than Br_2 would react more vigorously with a solution of I^-.

Chlorine has a higher electronegativity due to its smaller radius, therefore the reaction would be more vigorous

Name:_____

7. (i) Define the term *ionization energy*.

Energy required to remove 1 mol of e⁻ from 1 mol of gaseous atoms in their ground state.

(1)

(iii) State and explain the trend in the ionization energy of alkali metals down the group.

IE decreases down the group. The energy required to remove an electron decreases as distance from nucleus. Additionally, effective nuclear charge decreases since down the group there is more shielding.

(3)

8. In 1954 Linus Pauling was awarded the Chemistry Nobel Prize for his work on the nature of the chemical bond. Covalent bonds are one example of intramolecular bonding.

Explain the formation of the following.

(i) σ bonding

end to end overlap of s to s or p to s orbital along bonding/internuclear axis

(2)

(ii) π bonding

sideways overlap of p orbitals above/below axis

(2)

(iii) double bonds

2 pairs of e⁻ shared btw atoms; 1σ and 1π

(1)

(iv) triple bonds

3 pairs of e⁻ shared; 1σ 2π

9. An important compound of nitrogen is ammonia, NH_3. The chemistry of ammonia is influenced by its polarity and its ability to form hydrogen bonds. Polarity can be explained in terms of electronegativity.

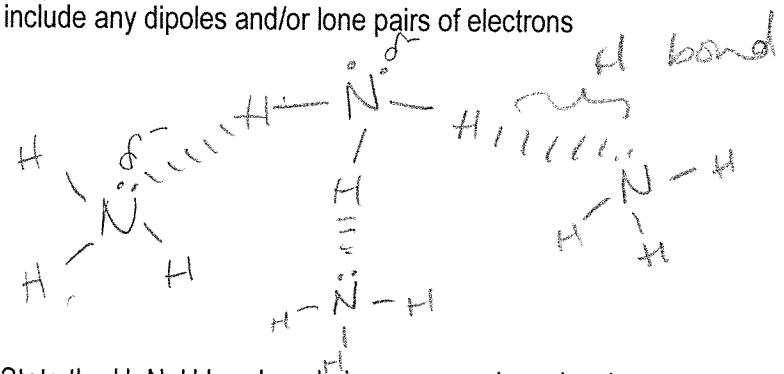
(a) (i) Explain the term *electronegativity*.

ability of atom to attract electrons in a covalent bond

(2)

Name:_____

(ii) Draw a diagram to show hydrogen bonding between two molecules of NH_3. The diagram should include any dipoles and/or lone pairs of electrons



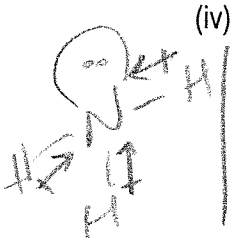
(3)

(iii) State the H–N–H bond angle in an ammonia molecule.

107°

(1)

(iv) Explain why the ammonia molecule is polar.



the lone pair causes the dipoles to not cancel, causing a net dipole (overall polarity) of the molecule, with a partial negative charge on the lone pair of N.

(1)

(b) Ammonia reacts with hydrogen ions forming ammonium ions, NH_4^+.

(i) State the H–N–H bond angle in an ammonium ion.

109.5°

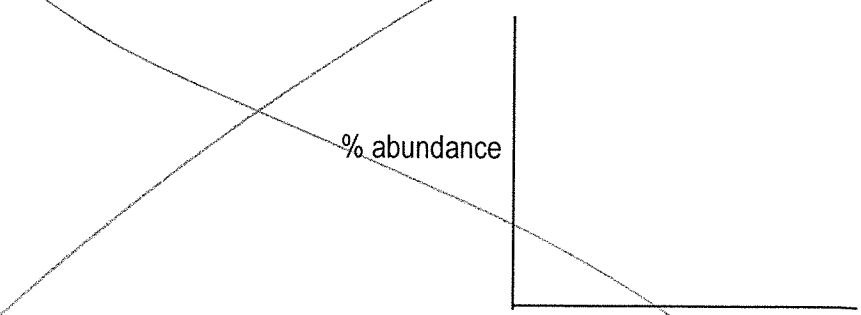
(1)

(ii) Explain why the H–N–H bond angle of NH_3 is different from the H–N–H bond angle of NH_4^+; referring to both species in your answer.

lone pair causes more repulsion, pushing the bonded H atoms closer making the overall bond angles smaller.

10. There are three isotopes of Silicon, ^{28}Si, ^{29}Si, and ^{30}S. The percent abundance ^{30}Si is 3.09%. Using this information and the periodic table, calculate the percent abundance of ^{28}S and ^{29}S, and sketch the mass spectra you would expect. Show your work.

repeat



11. A student measures a rectangle to have one side of length 3.2 ± 0.2 cm and measures the other side to have a length of 0.045 ± 0.002 meters. Calculate the area of the rectangle and include error.

Name:_____

12. A 0.64 ± 0.01g piece of Magnesium Metal is burned in oxygen gas. Calculate the number of moles Mg that were reacted, include error.

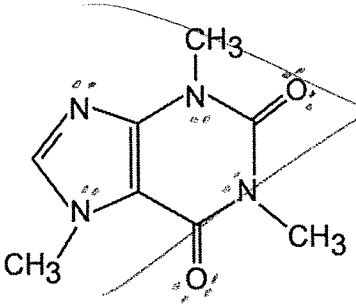
13. A 2.85 ± 0.05 cm piece of Mg is used to react in the previous question. Calculate the percent uncertainty from the given fractional uncertainty.

Repeat

14. (SKIP) 50.0 cm^3 of a 0.350 $mol*dm^{-3}$ solution of potassium chloride is added to 150. cm^3 of 0.125 $mol*dm^{-3}$ aqueous lead (II) nitrate. Write a balanced molecular equation, full ionic, and net ionic equation for the reaction, determine which reactant limits, and how much solid could theoretically be produced.

15. (SKIP)150.0 cm^3 of a 0.450 $mol*dm^{-3}$ solution of sodium carbonate is added to 50. cm^3 of 0.225 $mol*dm^{-3}$ aqueous magnesium nitrate. Write a balanced molecular equation, full ionic, and net ionic equation for the reaction, determine which reactant limits, and how much solid could theoretically be produced.

16. Draw the Lewis Structure of the Caffeine molecule below:



Repeat

17. Caffeine, a stimulant found in coffee, contains 49.5% C, 5.15% H, 28.9% N, and 16.5% O by mass and has a molar mass of 195 g/mol. Find its empirical and molecular formula

18. Iron (III) phosphate reacts with sodium sulfate to make iron (III) sulfate and sodium phosphate. Assume all reacts and products are in aqueous solution.
    a. Write a balanced chemical equation for the reaction including state symbols.

$2FePO_{4(aq)} + 3Na_2SO_{4(aq)} \rightarrow Fe_2(SO_4)_{3(aq)} + 2Na_3PO_{4(aq)}$

LR

Name:_____

b. If you react 25.00 g iron (III) phosphate with 25.00 g sodium sulfate, which would be the limiting reactant?

$25g\ FePO_4 \left|\frac{1mol}{150.8g}\right|\frac{1}{2}\left|\frac{402.6}{1}\right| = 33.37g$ produced

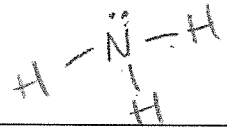
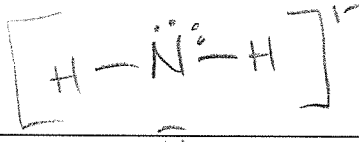
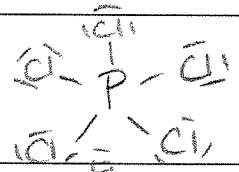
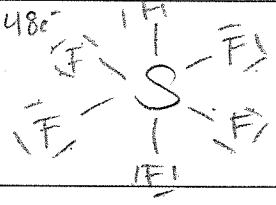
$25g\ Na_2SO_4 \left|\frac{1mol}{142g}\right|\frac{1}{3}\left|\frac{402.6}{1}\right| = 23.63g$ produced

c. How much iron (III) sulfate could you then theoretically produce?

23.63g

d. If 19.14 grams of iron (III) sulfate are actually produced when you perform this reaction in lab, what is the percent yield?

$\frac{19.14}{23.63} \times 100 = 81.00\%$

Molecule	Lewis Structure	Name of Shape	Bond Angle	Polar or nonpolar	Hybrid-ization
CO_2		linear	180°	Non	SP
BF_3		trigonal planar	120°	Non	SP^2
CF_4		tetrahedral	109.5°	Non	SP^3
NH_3		trigonal pyramidal	~107°	polar	SP^3
NH_2^-		bent	~105°	polar	SP^3
PCl_5		trigonal bipyramidal	90° 120°	non	SP^3d
SF_6	6+6(7)=48e⁻ 	octahedral	90° 180°	non	SP^3d^2

19. Magnesium has three stable isotopes- ^{24}Mg, ^{25}Mg, and ^{26}Mg. The lightest isotope (^{24}Mg) has a percent abundance of 78.90% calculate the percentage abundance of the other isotopes, and then predict the mass spectrum would look like based on your answer.

	%	frac
^{24}Mg	78.90%	.7890
^{25}Mg	x	x
^{26}Mg	21.1-x	.211-x

$24.3 = (24)(.789) + (25x) + (26)(.211-x)$

$24.3 = 18.936 + 25x + 5.486 - 26x$

$-.122 = -x$