SCH 3U1 **REVIEW FOR FINAL EXAM (Blacked out not on exam)**

ATOMIC THEORY

1. [redacted]
3. What causes line spectra?
4. According to Bohr, why do electrons travel in specific energy levels around the nucleus?
5. What is the difference between an "orbit" as described in the Bohr-Rutherford model of the atom and an "orbital" as described in the quantum mechanical model of the atom?
6. Draw the electron configuration for *Scandium, Sc*.
7. What are the characteristics of substances in the s, p and d blocks

UNIT ONE

1. What is the family name for Group 17?
2. Why does ionization energy increase from left to right in a period on the periodic table?
3. What is meant by the term "periodic trend"?
4. Explain how first ionization energy is related to atomic radius.
5. Which element has the smallest atomic radius?
6. Examine the following 1st, 2nd, and 3rd ionization energies and state which element is most likely a noble gas and which element is most likely in Group 1..

	1st (eV)	2nd (eV)	3rd (eV)
Element X	5.139	47.286	71.64
Element Y	7.646	15.035	80.143
Element Z	21.564	40.962	63.45

7. Explain why, in general, ionization energy and electron affinity follow the same trends throughout the periodic table.
8. For a science fair project, a student wants to design a simple device for removing certain gases from polluted air. He knows that polar molecules dissolve well in water, so he bubbles polluted air through a jug of water to remove unwanted gases. For his project, the student uses air containing the following gases:

1. $N_{2(g)}$
2. $O_{2(g)}$
3. $HF_{(g)}$
4. $NH_{3(g)}$
5. $CH_{4(g)}$
6. $OCl_{2(g)}$
7. $C_3H_{8(g)}$
8. $CH_3OCH_{3(g)}$

List the gases that will dissolve by writing down their corresponding numbers.

9. Draw Lewis diagrams to explain the empirical formula for the following substances.
(a) $KI_{(s)}$
(b) $Br_{2(l)}$
(c) $O_{2(g)}$
(d) $BaCl_{2(s)}$
10. Provide the name for the following acids.

(a) $HClO_{3(aq)}$	
(b) $HNO_{2(aq)}$	
(c) $HI_{(aq)}$	

11. Use electron dot diagrams to explain the formula for $CaCl_2$.
12. Draw the electron dot diagrams for ammonia and ammonium ion.
13. Predict the products and write a balanced chemical equation for the following chemical reaction: Copper wire is added to an aqueous solution of silver nitrate to recover the silver.
14. Predict the products and write a balanced chemical equation for the following chemical reaction: A nitric acid spill is neutralized by a barium hydroxide solution.
15. Predict the products and write a balanced chemical equation for the following chemical reaction: Steel wool is burned in a hot flame to produce a fireworks-like effect.
16. Predict the products and write a balanced chemical equation for the following chemical reaction: Scrap iron is added to an aqueous solution of copper(II) nitrate to recover the copper.
17. Predict the products and write a balanced chemical equation for the following chemical reaction: Aqueous aluminum chloride is added to a solution suspected to contain sodium carbonate.
18. Predict the products and write a balanced chemical equation for the following chemical reaction: Potassium metal is added to water.
19. Complete the following chemical reaction equation, including states of matter and balancing:
$FeCl_{3(aq)} + Zn_{(s)} \rightarrow$
20. Complete the following chemical reaction equation, including states of matter and balancing:
$C_2H_5OH_{(l)} + O_{2(g)} \rightarrow$

UNIT TWO

21. Explain the meaning of the term "stoichiometry."
22. State the definition of an "atomic mass unit."
23. Determine the number of carbon atoms found in 2.50 mol of methane, CH_4.
24. Calculate the number of moles of lead present in 8.6×10^{17} atoms of Pb.
25. Determine the number of hydrogen atoms found in 5.61 mol of magnesium hydroxide, $Mg(OH)_2$.
26. Calculate the number of fluoride ions present in 0.669 mol of barium fluoride, BaF_2.
27. Calculate the number of moles found in 168.0 g of iron(II) oxide.
28. Briefly state the difference between empirical and molecular formulas and provide an example of each.

29. Define the term "limiting reagent".
30. Balance the following equation by inspection: $H_2C_2O_4 + NaOH \rightarrow Na_2C_2O_4 + H_2O$
31. Balance the following equation by inspection: $Fe(OH)_3 + H_2SO_4 \rightarrow Fe_2(SO_4)_3 + H_2O$
32. Balance the following equation by inspection: $Bi_2O_3 + H_2 \rightarrow Bi + H_2O$
33. Balance the following equation by inspection: $Al_4C_3 + H_2O \rightarrow CH_4 + Al(OH)_3$
34. Balance the following equation by inspection: $Sb_2S_3 + O_2 \rightarrow Sb_2O_3 + SO_2$
35. Balance the following equation by inspection:
    $Al_2(SO_4)_3 + NH_3 + H_2O \rightarrow Al(OH)_3 + (NH_4)_2SO_4$
36. State the mole ratio between the reactants in the following balanced equation:
    $4NaOH + 2F_2 \rightarrow 4NaF + 2H_2O + O_2$
37. Consider the following balanced equation: $4ZnS + 6O_2 \rightarrow 4ZnO + 4SO_2$
    Determine the number of moles of zinc oxide produced when 2.5 mol of zinc sulfide is combined with excess O_2.
38. If 4.61 g of gold(I) oxide was the amount obtained in a reaction for which the theoretical yield was 8.14 g, determine the percentage yield.

UNIT THREE

39. As temperature increases, the solubility of $NaNO_3$ in water increases and the solubility of oxygen decreases. Give reasons for these different solubility trends.
40. Explain the difference between dilute and concentrated solutions.
41. Give an example of a solution with a gas dissolved in a gas.
42. Using the solubility table below, state whether the following ionic compounds are soluble or insoluble in water.

Compound	Soluble or insoluble
(a) PbI_2	
(b) $KClO_3$	
(c) $CaCO_3$	
(d) $BaSO_4$	

43. Differentiate between the terms saturated, unsaturated, and supersaturated.
44. A sample of well water is known to contain a high concentration of iron. What solution could you use to test the water to get a positive precipitate test for the dissolved iron?
45. Write the ionic equation to represent the dissociation of calcium hydroxide.
46. Consider the following reaction: Barium chloride solution is mixed with potassium sulphate solution to produce a solid precipitate barium sulphate and a solution of potassium chloride.
    For this reaction, write
    (a) a balanced chemical equation
    (b) a total ionic equation
    (c) a net ionic equation
47. Consider the following reaction: aqueous nickel(II) nitrate reacts with aqueous sodium sulphite.
    For this reaction, write
    (a) a balanced chemical equation
    (b) a total ionic equation
    (c) a net ionic equation
48. Refer to the solubility curves of various ionic compounds in water.
    (a) What mass of KCl can be dissolved in 100 mL of water at 60ºC?
    (b) What mass of KCl can be dissolved in 2.5 L of water at 30ºC?
49. A saturated solution of $KClO_3$ is cooled from 50ºC to 5ºC when it is placed into a fridge. Calculate how much potassium chlorate will crystallize from a 1.0-L solution.
50. Students in a chemistry lab are making the compound cobalt(II) carbonate. It can be made by reacting sodium carbonate solution with cobalt(II) chloride solution. Calculate the volume of 1.0 mol/L cobalt(II) chloride solution required to completely react with 250 mL of 1.5 mol/L sodium carbonate.
51. 100 mL of 0.2 mol/L sodium carbonate solution and 200 mL of 0.1 mol/L calcium nitrate solution are mixed together. Calculate the mass of calcium carbonate that would precipitate and the concentration of the sodium nitrate solution that will be produced.
52. A student wishes to precipitate all of the silver ions from 3.0 L of a 0.85 mol/L $AgNO_3$ solution. If the student is aiming to precipitate silver chloride, suggest and calculate an appropriate solute, concentration, and volume for a reacting solution.
53. 500 g of copper metal is reacted with 2.5 L of 3.0 mol/L nitric acid solution. Calculate how much of the copper metal remains after the reaction is complete.
54. A student mixed 100.0 mL of a 0.100 mol/L solution of barium chloride with 100.0 mL of a 0.100 mol/L solution of iron(III) sulphate. The barium sulphate precipitate was filtered, dried, and was measured to have a mass of 2.0 g. Calculate the % yield of the barium sulphate.
55. A 750 mL saturated solution of potassium sulphate has been prepared in the lab at a temperature of 20ºC. How much more potassium sulphate could be dissolved in this solution if it is heated to 70ºC?
56. Assume that the solubility of carbon dioxide gas in pop at 5ºC is 0.586 g/100 mL (supersaturated) and at 20ºC its solubility is 0.169 g/100 mL. What mass of carbon dioxide gas will escape from a 355-mL can of Coke that has been taken out of the fridge and has been sitting open at 20ºC?

57. Barium sulphate has a low solubility in water and is commonly used as a suspension in hospitals to be taken internally for abdominal X-rays. The solubility of barium sulphate at 20ºC is 0.25 mg/100 mL of water. If 1.5 g of barium sulphate is placed into 2.0 L of water, calculate the mass of precipitate that would settle to the bottom after a tiny amount dissolves at 20ºC?
58. The maximum quantity of oxygen that dissolves in water at 0ºC is 14.7 ppm and at 25ºC it is 8.7 ppm. Calculate the difference in the mass of oxygen that can be dissolved in 75 L of water at the two temperatures.

59. Define acid and base according to the Bronsted-Lowry theory.
60. Identify the two acid-base conjugate pairs in the following reaction:
$HF_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + F^-_{(aq)}$
61. Write a balanced chemical equation for the neutralization of aqueous perchloric acid by aqueous barium hydroxide.

UNIT FOUR

62. What are the three types of motion for particles?
63. Use the kinetic molecular theory to explain why the pressure increases in a tire when it has been driven for a long period of time on a hot afternoon.
64. Explain Charles's law using the kinetic molecular theory.
65. Solve for the missing variable in the following chart:

P_1	P_2	T_1	T_2
101 kPa	125 kPa	450 K	?

66. Solve for the missing variable in the following chart:

V_1	V_2	T_1	T_2
101 L	125 L	450 K	?

67. Complete the following chart, assuming that the initial conditions were taken at SATP:

P_1	V_1	T_1	P_2	V_2	T_2
			125 kPa	15.5 L	375 K

68. What would the net effect on the volume of an ideal gas be if the absolute temperature is decreased by one-half and the pressure is doubled?
69. A bubble of methane gas, CH_4, is released from a deep bog. The temperature at the bottom of the bog is 12ºC with a pressure of 375 kPa. If the bubble has a volume of 475 mL at the bottom, what will the new volume be, just underneath the surface of the bog water level, if the outside temperature is 35ºC and the pressure is 99.5 kPa?

70. Butane from a lighter undergoes combustion in the following manner:
$2C_4H_{10\,(g)} + 13O_{2\,(g)} \rightarrow 8CO_{2\,(g)} + 10\,H_2O_{(g)}$
What volume of butane was burned to produce 325 mL of $CO_{2\,(g)}$?
71. State Avogadro's theory.

SCH 3U GRADE 11 REVIEW

SHORT ANSWER

ATOMIC THEORY

1. ANS:

↑↓
4s

↑↓ ↑↓ ↑↓
3p

↑↓
3s

↑↓ ↑↓ ↑↓
2p

↑↓
2s

↑↓
1s

2. ANS:

↑↓ ↑ ↑
2p

↑↓
2s

↑↓
1s

$1s^2 2s^2 2p^4$

Pauli exclusion principle states that no two electrons can have the same four quantum numbers, therefore each orbital can hold only two electrons with opposite spins. Hund's rule says that the electrons in orbitals with the same energy are half filled first before more are added. Also, the electrons in those half filled orbitals must have the same spin.

3. ANS:
Electrons can only absorb specific amounts of energy. When they lose that energy, it corresponds to specific colours of light as opposed to a spectrum.

4. ANS:
Electrons may only possess specific amounts of energy thus they can only exist at specific distances from the nucleus.

5. An orbit is a path on which an electron travels around the nucleus. It is thus two dimensional. An orbital is a region of space in which there is a high probability of finding an electron. It is three dimensional.

6. ANS:

↑
3d

↑↓
4s

↑↓ ↑↓ ↑↓
3p

↑↓
3s

↑↓ ↑↓ ↑↓
2p

↑↓
2s

↑↓
1s

7. ANS:
- s - reactive, metals, solids, mono-valent
- p - varied, some gases and liquids as well as solids
- d - metals but not as reactive as s block, multivalent

1. ANS: halogens
2. ANS:
Ionization energy increases because atomic radius decreases. This happens because the nuclear charge increases, but the number of energy levels does not. Therefore, the nucleus has a stronger hold on the electrons as the nuclear charge increases.

3. ANS:

A periodic trend is one that repeats at regular intervals.

4. ANS:
The smaller the atomic radius, the stronger the nucleus holds its electrons and the harder it is to remove an electron. The harder it is to remove an electron, the higher the first ionization energy.
5. ANS:
helium

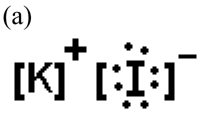
6. ANS:
element Z

ANS:
element X

7. ANS:
They are both dependent on the same thing, atomic radius. When the atomic radius is small, it is more difficult to remove an electron, so ionization energy is high. At the same time, it is easier for the atom to accept another electron, so it releases energy when an electron is added and electron affinity is high.

8. ANS:
3, 4, 6, and 8

9. ANS:
(a)



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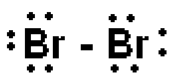

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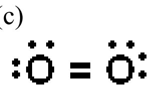

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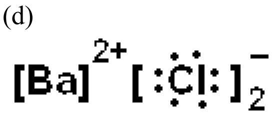
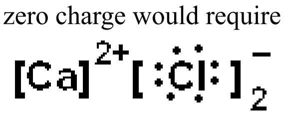


10. ANS:

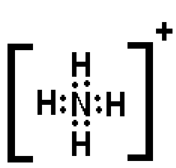
	Classical name
(a) $HClO_{3(aq)}$	chloric acid
(b) $HNO_{2(aq)}$	nitrous acid
(c) $HI_{(aq)}$	hydroiodic acid

11. ANS:
Calcium forms an ion with a 2+ charge and chlorine forms an ion with a 1^- charge. This means that the smallest unit with a zero charge would require one calcium ion and two chloride ions.

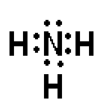


12. ANS:

ammonium ion



ammonia



13. ANS:
$Cu_{(s)} + 2AgNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + Ag_{(s)}$

14. ANS:
$2HNO_{3(aq)} + Ba(OH)_{2(aq)} \rightarrow 2HOH_{(l)} + Ba(NO_3)_{2(aq)}$

15. ANS:
$4Fe_{(s)} + 3O_{2(g)} \rightarrow 2Fe_2O_{3(s)}$

16. ANS:
$2Fe_{(s)} + 3Cu(NO_3)_{2(aq)} \rightarrow 3Cu_{(s)} + 2Fe(NO_3)_{3(aq)}$

17. ANS:
$2AlCl_{3(aq)} + 3Na_2CO_{3(aq)} \rightarrow Al_2(CO_3)_{3(s)} + 6NaCl_{(aq)}$

18. ANS:
$2K_{(s)} + 2HOH_{(l)} \rightarrow H_{2(g)} + 2KOH_{(aq)}$

19. ANS:
$2FeCl_{3(aq)} + 3Zn_{(s)} \rightarrow 3ZnCl_{2(aq)} + 2Fe_{(s)}$
20. ANS:
$C_2H_5OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(g)}$

21. ANS:
Stoichiometry is the study of relationships between the quantities of reactants and products that participate in chemical reactions.

22. ANS:
One atomic mass unit is defined as $\frac{1}{12}$ the mass of a carbon-12 atom.
23. ANS:
$$N_{CH_4} = nN_A$$
$$= 2.50 \text{ mol} \times \frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol}}$$
$$= 1.51 \times 10^{24} \text{ molecules}$$
Since there is one carbon atom in each methane molecule, there are 1.51×10^{24} atoms of carbon present.

24. ANS:
$$n_{Pb} = 8.6 \times 10^{17} \text{ atoms} \times \frac{1.0 \text{ mol}}{6.02 \times 10^{23} \text{ atoms}}$$
$$= 1.4 \times 10^{-6} \text{ mol}$$

25. ANS:
$$N_{Mg(OH)_2} = nN_A$$
$$= 5.61 \text{ mol} \times \frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol}}$$
$$= 3.38 \times 10^{24} \text{ units}$$
Since there are two hydrogen atoms in each magnesium hydroxide unit, there are 6.76×10^{24} atoms of hydrogen present.

26. ANS:
$$N_{BaF_2} = nN_A$$
$$= 0.669 \text{ mol} \times \frac{6.02 \times 10^{23} \text{ formula units}}{1 \text{ mol}}$$
$$= 4.03 \times 10^{23} \text{ formula units}$$
There are 4.03×10^{23} formula units in 0.669 mol of BaF_2. There are two F^- ions in each formula unit. Therefore, there are 8.06×10^{23} F^- ions present in this sample.

27. ANS:
$$m = 168.0 \text{ g}$$
$$M = (1 \times 55.85) + (1 \times 16.00)$$
$$= 71.85 \text{ g/mol}$$
$$n_{FeO} = 168.0 \text{ g} \times \frac{1 \text{ mol}}{71.85 \text{ g}}$$
$$= 2.338 \text{ mol}$$
A mass of 168.0 g of iron(II) oxide is equivalent to 2.338 mol.

28. ANS:
A molecular formula shows the actual number of atoms of each element in a molecule of a compound. ($C_6H_{12}O_6$)
An empirical formula is the simplest formula and shows only the relative number of moles of each type of atom in a compound. (CH_2O)

29. ANS:
The limiting reagent is the first reactant in a chemical reaction to be completely consumed before the remaining reactant(s) is/are.

30. ANS:
$H_2C_2O_4 + 2NaOH \rightarrow Na_2C_2O_4 + 2H_2O$

31. ANS:
$2Fe(OH)_3 + 3H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 6H_2O$

32. ANS:
$Bi_2O_3 + 3H_2 \rightarrow 2Bi + 3H_2O$

33. ANS:
$Al_4C_3 + 12H_2O \rightarrow 3CH_4 + 4Al(OH)_3$

34. ANS:
$2Sb_2S_3 + 9\,O_2 \rightarrow 2Sb_2O_3 + 6SO_2$

35. ANS:
$Al_2(SO_4)_3 + 6NH_3 + 6H_2O \rightarrow 2Al(OH)_3 + 3(NH_4)_2SO_4$

36. ANS:
$NaOH:F_2 = 2:1$

37. ANS:
$n_{ZnS} = 2.5 \text{ mol}$
mole ratio ZnS:ZnO = 1:1
$n_{ZnO} = n_{ZnS} = 2.5 \text{ mol}$

38. ANS:
$$\text{percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$
$$= \frac{4.61\text{ g}}{8.14\text{ g}} \times 100\%$$
$$= 56.6\%$$

39. ANS:
Sodium nitrate is an ionic solid and will dissolve more easily as temperature increases because warmer water has greater heat energy to overcome the attractive forces between the sodium and nitrate ions. Oxygen is a gas and its molecules must gain more energy to overcome the attractive forces of the water molecules and escape the solution.

40. ANS:
Dilute solutions contain very little dissolved solute in the solvent. Concentrated solutions contain a relatively large amount of dissolved solute in the solvent.

41. ANS:
Air is a solution of nitrogen, oxygen, and trace amounts of other gases.

42. ANS:

Compound	**Soluble or insoluble**
(a) PbI_2	insoluble
(b) $KClO_3$	soluble
(c) $CaCO_3$	insoluble
(d) $BaSO_4$	insoluble

43. ANS:
A saturated solution is one that cannot dissolve any more solute at a specific temperature. An unsaturated solution is one that contains less solute than it can usually hold at a given temperature. A supersaturated solution is one that contains more solute than it can usually hold at a given temperature.

44. ANS:
A sodium hydroxide solution. (There are several other possibilities that students could choose by using a solubility rules table.)

45. ANS:
$Ca(OH)_{2(s)} \rightarrow Ca^{2+}_{(aq)} + 2OH^-_{(aq)}$

46. ANS:
(a) $BaCl_{2(aq)} + K_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + 2KCl_{(aq)}$
(b) $Ba^{2+}_{(aq)} + \cancel{2Cl^-_{(aq)}} + \cancel{2K^+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4\,(s)} + \cancel{2K^+}_{(aq)} + \cancel{2Cl^-}_{(aq)}$
(c) $Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4(s)}$

47. ANS:
(a) $Ni(NO_3)_{2(aq)} + Na_2SO_{3(aq)} \rightarrow NiSO_{3(s)} + 2NaNO_{3(aq)}$

(b) $Ni^{2+}_{(aq)} + \cancel{2NO_3^-}_{(aq)} + \cancel{2Na^+}_{(aq)} + SO_3^{2-}_{(aq)} \rightarrow NiSO_{3(s)} + \cancel{2Na^+}_{(aq)} + \cancel{2\ NO_3^-}_{(aq)}$
(c) $Ni^{2+}_{(aq)} + SO_3^{2-}_{(aq)} \rightarrow NiSO_{3(s)}$

48. ANS:
(a) mass of KCl dissolved at 60ºC = 45 g/100mL
A saturated KCl solution has 45 g of dissolved KCl per 100 mL of water at 60ºC.

(b) solubility of a saturated solution of KCl at 30ºC

$$\frac{36\text{ g}}{100\text{ mL}} = \frac{x}{2500\text{ mL}}$$

$$(100\text{ mL})x = (36\text{ g})(2500\text{ mL})$$

$$x = \frac{(36\text{ g})(2500\text{ mL})}{100\text{ mL}}$$

$$= 900\text{ g}$$

The mass of KCl that can be dissolved in 2.5 L of water at 30ºC is 900 g.

49. ANS:

solubility of $KClO_3$ at 50ºC = $\frac{19\text{ g}}{100\text{ mL}}$

solubility of $KClO_3$ at 5ºC = $\frac{4\text{ g}}{100\text{ mL}}$

mass of $KClO_3$ crystallizing = $19\text{ g} - 4\text{ g} = \frac{15\text{ g}}{100\text{ mL}}$

$$\frac{15\text{ g}}{100\text{ mL}} = \frac{m}{1000\text{ mL}}$$

$$(14\text{ g})(1000\text{ mL}) = (100\text{ mL})m$$

$$m = \frac{(14\text{ g})(1000\text{ mL})}{100\text{ mL}}$$

$$= 150\text{ g}$$

The mass of potassium chlorate that will crystallize from a 1.0-L solution is 150 g.

50. ANS:
$Na_2CO_{3(aq)} + CoCl_{2(aq)} \rightarrow CoCO_{3(s)} + 2\ NaCl_{(aq)}$
250 mL $\quad v$
1.5 mol/L $\quad$ 1.0 mol/L

$$C = \frac{n}{v}$$

$$n_{Na_2CO_3} = v \times C$$

$$= (0.250\text{ L}) \times \frac{(1.5\text{ mol})}{1\text{ L}}$$

$$= 0.38\text{ mol}$$

$$n_{CoCl_2} = 0.38\text{ mol} \times \frac{1}{1}$$

$$= 0.38\text{ mol}$$

$$v_{CoCl_2} = 0.38\text{ mol} \times \frac{1\text{ L}}{1\text{ mol}}$$

$$= 0.38\text{ L or } 380\text{ mL}$$

The volume of cobalt(II) chloride required is 380 mL.

51. ANS:
$Na_2CO_{3(aq)} + Ca(NO_3)_{2(aq)} \rightarrow CaCO_{3(s)} + 2NaNO_{3(aq)}$
100 mL $\quad$ 200 mL $\quad$ m $\quad$ C
0.20 mol/L $\quad$ 0.10 mol/L

$$C = \frac{n}{v}$$

$$n_{Na_2CO_3} = v \times C \qquad n_{Ca(NO_3)_2} = v \times C$$

$$= 0.100\ \text{L} \times 0.20\ \text{mol/L} \qquad = 0.200\ \text{L} \times 0.10\ \text{mol/L}$$

$$= 0.020\ \text{mol} \qquad = 0.020\ \text{mol}$$

Since one mole of Na_2CO_3 reacts completely with one mole of $Ca(NO_3)_2$ from the equation, then this mixing of solutions will be a complete reaction.

$$m_{CaCO_3} = 0.020\ \text{mol}\ Na_2CO_3 \times \frac{1\ \text{mol}\ CaCO_3}{1\ \text{mol}\ Na_2CO_3} \times \frac{100.09\ \text{g}}{1\ \text{mol}\ CaCO_3}$$

$$= 2\ \text{g}$$

The mass of calcium carbonate that precipitates is 2 g.

$$C_{NaNO_3} = \frac{2 \times 0.02\ \text{mol}}{0.100\ \text{L} + 0.200\ \text{L}}$$

$$= \frac{0.04\ \text{mol}}{0.300\ \text{L}}$$

$$= 0.1\ \text{mol/L}$$

The concentration of the sodium nitrate solution is 0.1 mol/L.

52. ANS:

$AgNO_{3(aq)} + KCl_{(aq)} \rightarrow AgCl_{(s)} + KNO_{3(aq)}$

3.0 L $\quad v$

0.85 mol/L $\quad C$

$$C = \frac{n}{v}$$

$$n_{AgNO_3} = C \times v$$

$$= \frac{0.85\ \text{mol}}{\text{L}} \times 3.0\ \text{L}$$

$$= 2.6\ \text{mol}$$

Since 1 mol of silver nitrate reacts with 1 mol of potassium chloride, then 2.6 mol of potassium chloride will be required.

$$C_{KCl} = \frac{n}{v}$$

$$= \frac{2.6\ \text{mol}}{1.0\ \text{L}}$$

$$= 2.6\ \text{mol/L}$$

An appropriate solute could be potassium chloride with a concentration of 2.6 mol/L. The student could use a 1.0-L volume of this solution.

53. ANS:

$3Cu_{(s)} + 8HNO_{3(aq)} \rightarrow 4H_2O_{(g)} + 3Cu(NO_3)_{2(aq)} + 2NO_{(g)}$

500 g $\quad$ 2.5 L

m $\quad$ 3.0 mol/L

$$n_{HNO_3} = v \times C$$

$$= 2.5\ \text{L} \times 3.0\ \text{mol/L}$$

$$= 7.5\ \text{mol}$$

$$n_{Cu} = 500\ \text{g} \times \frac{1\ \text{mol}}{63.55\ \text{g}}$$

$$= 7.87\ \text{mol}$$

$$n_{Cu\ (reacted)} = 7.5\ \text{mol}\ HNO_3 \times \frac{3\ \text{mol}\ Cu}{8\ \text{mol}\ HNO_3}$$

$$= 2.8\ \text{mol}$$

$$n_{Cu\,(unreacted)} = n_{Cu\,(have)} - n_{Cu\,(reacted)}$$

$$= 7.87\text{ mol} - 2.8\text{ mol}$$

$$= 5.07\text{ mol}$$

$$m_{Cu\,(left)} = 5.07\text{ mol} \times \frac{63.55\text{ g}}{1\text{ mol}}$$

$$= 320\text{ g}$$

The mass of copper metal left unreacted is 320 g.

54. ANS:

$3BaCl_{2(aq)} + Fe_2(SO_4)_{3(aq)} \rightarrow 3BaSO_{4(s)} + 2FeCl_{3(aq)}$

100.0 mL	100.0 mL	*m*
0.100 mol/L	0.100 mol/L	

$$n_{BaSO_4} = 0.100\text{ L} \times 0.100\text{ mol/L } BaCl_2 \times \frac{3\text{ mol } BaSO_4}{3\text{ mol } BaCl_2}$$

$$= 0.01\text{ mol}$$

$$m_{BaSO_4} = 0.01\text{ mol} \times \frac{233.39\text{ g}}{1\text{ mol}}$$

$$= 2.3\text{ g}$$

The theoretical mass of barium sulphate is 2.3 g.

$$\%\text{ yield } BaSO_4 = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$= \frac{2.0\text{ g}}{2.3\text{ g}} \times 100$$

$$= 87\,\%$$

The % yield of the barium sulphate precipitate was 87%.

55. ANS:

solubility of K_2SO_4 at 20ºC = $\frac{11\text{ g}}{100\text{ mL}}$

solubility of K_2SO_4 at 70ºC = $\frac{20\text{ g}}{100\text{ mL}}$

$$m_{K_2SO_4} = \frac{20\text{ g} - 11\text{ g}}{100\text{ mL}}$$

$$= \frac{9\text{ g}}{100\text{ mL}}$$

$$m_{K_2SO_4} = \frac{m}{750\text{ mL}}$$

$$\frac{9\text{ g}}{100\text{ mL}} = \frac{m}{750\text{ mL}}$$

$$m = 9\text{ g} \times \frac{750\text{ mL}}{100\text{ mL}}$$

$$= 68\text{ g}$$

The extra mass of potassium sulphate that could be dissolved is 68 g.

56. ANS:

$$m_{CO_2} = \frac{0.586\text{ g} - 0.169\text{ g}}{100\text{ mL}}$$

$$= \frac{0.417\text{ g}}{100\text{ mL}}$$

$$m_{CO_2} = \frac{m}{355 \text{ mL}}$$

$$\frac{m}{355 \text{ mL}} = \frac{0.417 \text{ g}}{100 \text{ mL}}$$

$$m = 0.417 \text{ g} \times \frac{355 \text{ mL}}{100 \text{ mL}}$$

$$= 1.48 \text{ g}$$

The mass of carbon dioxide bubbling out of the Coke is 1.48 g.

57. ANS:

$$BaSO_4 \text{ solubility} = \frac{0.25 \text{ mg}}{100 \text{ mL}} = \frac{s}{2000 \text{ mL}}$$

$$s = \frac{2000 \text{ mL} \times 0.25 \text{ mg}}{100 \text{ mL}}$$

$$= 5 \text{ mg}$$

$$\text{mass of } BaSO_4 \text{ precipitate} = 1.5 \text{ g} - 0.005 \text{ g}$$

$$= 1.5 \text{ g}$$

The mass of the barium sulphate precipitate is 1.5 g.

58. ANS:

$$m_{O_2} = \frac{14.7 \text{ mg} - 8.7 \text{ mg}}{1 \text{ L}}$$

$$= \frac{6.0 \text{ mg}}{1 \text{ L}}$$

$$m_{O_2} = \frac{6.0 \text{ mg}}{1 \text{ L}} = \frac{\text{m}}{75 \text{ L}}$$

$$m = 6.0 \text{ mg/L} \times 75 \text{ L}$$

$$= 450 \text{ mg}$$

The difference in the mass of oxygen dissolved at the two temperatures is 450 mg.

59. ANS:
A Bronsted acid is a proton donor. A Bronsted base is a proton acceptor.

60. ANS:
$HF_{(aq)}$ and $F^-_{(aq)}$ are conjugate acid-base pairs. $H_3O^+_{(aq)}$ and $H_2O_{(l)}$ are conjugate acid-base pairs.

61. ANS:
$2HClO_{4(aq)} + Ba(OH)_{2(aq)} \rightarrow Ba(ClO_4)_{2(aq)} + 2H_2O_{(l)}$

62. ANS:
translational, rotational, and vibrational motions

63. ANS:
As temperature rises, the particles move more rapidly and this increases the number of collisions with the sides of the tire. Greater force per unit area increases the pressure.

64. ANS:
Assume that the pressure and number of molecules of a gas are constant. As the temperature increases, the particles gain more energy, thereby increasing the distance separating the individual gas particles. As the distance increases, so does the volume, because gases always occupy the entire volume of their containers. As the particles lose kinetic energy (i.e., are cooled), the particles get closer together and reduce the total volume that they occupy. The individual size of the particles do not change and are considered dimensionless points in this theory.

65. ANS:

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$T_2 = \frac{P_2 T_1}{P_1}$$

$$= \frac{125 \text{ kPa} \times 450 \text{ K}}{101 \text{ kPa}}$$

$$= 557 \text{ K}$$

66. ANS:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$T_2 = \frac{V_2 T_1}{V_1}$$

$$= \frac{125\ \text{L} \times 450\ \text{K}}{101\ \text{L}}$$

$$= 557\ \text{K}$$

67. ANS:

P_1	V_1	T_1	P_2	V_2	T_2
100 kPa		298 K	125 kPa	15.5 L	375 K

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$V_1 = \frac{P_2 V_2 T_1}{P_1 T_2}$$

$$= \frac{125\ \text{kPa} \times 15.5\ \text{L} \times 298\ \text{K}}{100\ \text{kPa} \times 375\ \text{K}}$$

$$= 15.4\ \text{L}$$

68. ANS:

Both of these changes are negative growth factors, hence, the volume of the gas will be reduced to $\frac{1}{4}$ of its original volume.

69. ANS:

P_1	V_1	T_1	P_2	V_2	T_2
375 kPa	475 mL	12ºC = 285K	99.5 kPa		308 K

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$V_2 = \frac{P_1 V_1 T_2}{P_2 T_1}$$

$$= \frac{375\ \text{kPa} \times 475\ \text{mL} \times 308\ \text{K}}{99.5\ \text{kPa} \times 285\ \text{K}}$$

$$= 1934.67\ \text{mL}$$

$$= 1.93 \times 103\ \text{mL or } 1.93\ \text{L}$$

70. ANS:

$$V_{\text{butane}} = 325\ \text{mL CO}_2 \times \frac{2\ \text{C}_4\text{H}_{10}}{8\ \text{CO}_2}$$

$$= 81.2\ \text{mL}$$

71. ANS:
Equal volumes of gases at the same temperature and pressure contain an equal number of molecules.