Chemical Reactions

1. Complete the following table:

Formula	IUPAC Name
$CaCl_2$	calcium chloride
K_2CO_3	potassium carbonate
$Fe(NO_3)_3$	iron(III) nitrate
$(NH_4)_2SO_4$	ammonium sulphate
I_2O_5	diiodine pentoxide
$Mg(OH)_2$	magnesium hydroxide

2. Gallium has two naturally occuring isotopes 69Ga (60.1% abundance) and 71Ga (39.9% abundance). Calculate the atomic weight of naturally occuring gallium.

atomic weight = 0.601 x 69 + 0.399 x 71 = 69.8 g/mol

3. What is the correct formula for the compound sodium sulfite?

A. Na_2SO_3
B. Na_2SO_4
C. Na_2S
D. $NaHSO_3$

4. Calculate the molar mass of the following substances.

a) $Mg(OH)_2$

24.31 + 2(16.00) + 2(1.01) = 58.33g/mol

b) F_2

2 (19.00) = 38 g/mol

c) NO_3^-

14.01 + 3(16.00) = 62.01g/mol

5. Balance the following reactions

(a)		$2\ H_2S(g)$	+	$SO_2(g)$	$\rightarrow$	**2** $H_2O(l)$	+	**3** $S(s)$		
(b)	$Cu(s)$ +	**4** H^+	+	**2** NO_3^-	$\rightarrow$	Cu^{2+} +	**2** $NO_2(g)$	+	**2** H_2O	
(c)		$C_6H_{12}(l)$ +		**9** $O_2(g)$	$\rightarrow$	**6** $CO_2(g)$ +			**6** $H_2O(g)$	

6. Write a balanced chemical equation, for each of the following reactions, including only those species that actually take part in the reactions. (i.e. omit all spectator species)

a) Solid magnesium carbonate ($MgCO_3$) reacts with nitric acid (HNO_3) to produce a colourless conducting solution, carbon dioxide and water.

$$MgCO_3(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + CO_2(g) + H_2O(l)$$

b) Sodium metal burns in chlorine gas to produce solid sodium chloride.

$$2\ Na(s) + Cl_2(g) \rightarrow 2\ NaCl_{(s)}$$

c) Potassium chloride (KCl) solution is added to lead(II) nitrate ($Pb(NO_3)_2$) solution producing a white precipitate and a colourless conducting solution. What is the net ionic equation for this reaction?

$$Pb^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s)$$

d) Solid copper(II) nitrate is decomposed by heat to form solid copper(II) oxide, nitrogen dioxide gas and oxygen gas.

$$2\ Cu(NO_3)_2 \rightarrow 2\ CuO + 4\ NO_2 + O_2$$

7. For the questions below, predict the reactants, include states, balance the reaction and state what type of reaction it is.

a) $(NH_4)_2CO_{3(aq)} + CuCl_{2(aq)} \rightarrow 2\ NH_4Cl_{(aq)} + Cu(CO_3)_{2(s)}$

Type: **Double replacement**

b) $F_{2(g)} + 2\ KCl_{(aq)} \rightarrow Cl_{2(g)} + 2KF_{(aq)}$

Type: **Singe Replacement**

c) $2H_{2(g)} + O_{2(g)} \rightarrow$

Type: **Synthesis**

d) $CCl_{4(s)} \rightarrow C_{(s)} + 2Cl_{2(g)}$

Type: **Decomposition**

e) $3Mg(OH)_{2(aq)} + 2H_3PO_{4(aq)} \rightarrow Mg_3(PO_4)_{2(aq)} + 6H_2O_{(l)}$

Type: **Double replacement**

8. Describe the concept of the mole and its importance to measurement in chemistry.

Without the mole, amounts of reactants and products in chemical equations could not be predicted—unless all chemicals are gases at STP—since different compounds have different masses. Furthermore, since Avogadro's number is so large, tangible amounts of very small particles may be measured very precisely.

9. Convert each of the following into moles.

a) 12.04×10^{23} molecules of H_2

$$\frac{12.04 \times 10^{23}}{6.02 \times 10^{23}} = 2 \text{ mol}$$

b) 33.50 g of solid NaCl 22.9g + 35.45 = 58.35

$$\frac{33.50\text{g}}{58.53} = 0.572 \text{ mol}$$

c) 67.2 L of CO_2 at STP

$$67.2 \text{ L} \times \frac{1\text{mol}}{22.4\text{L}} = 3.00 \text{ mol } CO_2$$

10. How many grams of H_2 are there in 44.8 L?

$$44.8\text{L} \times \frac{1\text{mol}}{22.4\text{L}} = 2\text{mol} \times \frac{2.02\text{g}}{1\text{mol}} = 4.04\text{g of } H_2$$

11. Calculate the percentage by mass of carbon in sugar, $C_{12}H_{22}O_{11}$

$$M(C_{12}) = 144.12 \times \frac{100}{342.30}$$

$$= 42.10342 \text{ g}$$

$M(C_{12}) = 144.12$

$M(C_{12}H_{22}O_{11}) = 342.30$

∴percentage of carbon in sugar is 42.10 %

12. Calculate the empirical formula for a compound that has 43.7 g P (phosphorus) and 56.3 grams of oxygen.

$$\frac{43.7\text{ grams P}}{}\times\frac{1\text{ mol}}{30.97\text{ grams}}=1.41\text{ moles}$$

$$\frac{56.3\text{ grams O}}{}\times\frac{1\text{ mol}}{16.00\text{ grams}}=3.52\text{ moles}$$

$$\textit{Phosphorus}\ \frac{1.41}{1.41}=1.00$$

$$\textit{Oxygen}\ \frac{3.52}{1.41}=2.50$$

The answer = P_2O_5

13. Use the following equation to answer the questions below

$$4\ KO_2(s) + 2\ CO_2(g) \rightarrow 2\ K_2CO_3(s) + 3\ O_2(l)$$

a) How many **moles** of O_2 would be produced from 5 moles of exhaled CO_2?

$$5\text{mol } CO_2 \times \frac{3\text{ mol } O_2}{2\text{ mol } CO_2} = 7.5\text{ mol } CO_2$$

b) How many **moles** of KO_2 would be required to produce 9 moles of O_2?

$$9\text{mol } O_2 \times \frac{4\text{ mol } KO_2}{3\text{ mol } O_2} = 12\text{ mol } KO_2$$

c) What mass of K_2CO_3 would be produced from 50.0 g of KO_2?

[molar mass = 138.1 g mol^{-1}] [molar mass = 71.1 g mol^{-1}]

$$50\text{g } KO_2 \times \frac{1\text{mol}}{71.1\text{g}} = 0.70\text{mol} \times \frac{2\text{ mol } K_2CO_3}{4\text{ mol } KO_2} = 0.35\text{mol } K_2CO_3 \times \frac{138.1\text{g}}{1\text{mol}} = 48.6\text{g}$$

14. At a refinery, hydrogen gas (H_2) is used in the production of nickel. This gas is produced by the water-gas reaction using methane (CH_4):

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3\ H_2(g)$$

How many grams of hydrogen gas would be obtained if 10.6 kg of methane was reacted with excess water?

mass of hydrogen gas is 4.01×10^3 g

Gases and the Atmosphere Exam Review

1. If the weather forecast stated that the pressure is 104.2kPa

a) What is the pressure in atmospheres?

$$104.2\text{kPa} \times \frac{1\text{atm}}{101.3\text{kPa}} = 1.03\text{atm}$$

b) What would a barometer measure in mm of mercury?

$$104.2\text{kPa} \times \frac{760\text{mmHg}}{101.3\text{kPa}} = 781.7\text{mmHg}$$

2. A closed monometer is filled with mercury and connected to a container of oxygen. The difference is height of the mercury in the two arms is 124mm. What is the pressure, in kilopascals, of the oxygen.

$$124\text{mmHg} \times \frac{101.3\text{kPa}}{760\text{mmHg}} = 16.5\text{kPa}$$

3. An open monometer is filled with mercury and connected to a container of nitrogen. The level of the mercury is 12mm higher on the tube connected to the open air. If the air pressure is 743mmHg what is the pressure of nitrogen in atm?

$$743\text{mmHg} + 12\text{mmHg} = 755\text{mmHg}$$

$$755\text{mmHg} \times \frac{1\text{atm}}{760\text{mmHg}} = 0.99\text{atm}$$

4. If the initial temperature and pressure of a gas are 25°C and 5atm. What is the temperature when the pressure changes to 8atm?

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \qquad \frac{5\text{atm}}{298\text{K}} = \frac{8\text{atm}}{T_2} \qquad T_2 = 477\text{K} \text{ or } 204^\circ\text{C}$$

5. If the initial temperature and volume of a gas is 30°C and 2L. What is the volume when the pressure is -25°C?

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad \frac{2\text{L}}{303\text{K}} = \frac{V_2}{248\text{K}} \qquad V_2 = 1.64\text{L}$$

6. A gas at 1.5L is compressed to 0.5L and is kept at a constant temperature. What would the final pressure be if the initial pressure was 2.5atm?

$$V_1 \times P_1 = V_{2_2} \times P_2$$

$$1.5L \times 2.5atm = 0.5L \times P_2$$

$$P_2 = 7.5atm$$

7. a) How does increasing the volume of a gas effect its pressure, assuming that temperature remains the same.

Pressure and volume are inversely proportional, therefore if you increase the volume of a gas you will decrease the pressure.

b) What happens to the particles for this phenomenon to occur?

When the volume of a container is increased it increases the space between molecules and therefore there are fewer collisions between the molecules and the side of the container.

8. A gas occupies 450mL at 1.4atm and 223K. At what pressure will the gas occupy 290ml at 300K?

$$\frac{V_1 \times P_1}{T_1} = \frac{V_{2_2} \times P_2}{T_2}$$

$$\frac{450mL \times 1.4atm}{223K} = \frac{290mL \times P_2}{300K}$$

$$P_2 = 2.9atm$$

9) A sample of hydrogen gas has volume of 305mL when the temperature is 25°C and the pressure is 41.5kPa. What volume will the gas occupy at STP? (STP Temperature = 273K Pressure= 101.3kPa)

$$\frac{V_1 \times P_1}{T_1} = \frac{V_{2_2} \times P_2}{T_2}$$

$$\frac{305mL \times 41.5kPa}{298K} = \frac{V_2 \times 101.3kPa}{273K}$$

$$V_2 = 114mL$$

Solutions

1. Provide an example for each of the following solution types

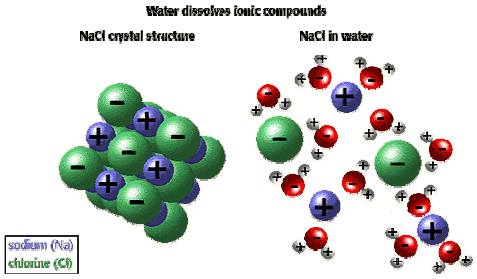
a) Solid in liquid- salt in water
Iodide in alcohol

b) Gas in Liquid- carbon dioxide in beverages
oxygen in water

2. What are two physical characteristics of water that make it an important molecule in nature.

- polar molecule, very good solvent
- ice is less dense than liquid (lakes don't freeze solid)
- it is a liquid between 0and 100°C
- it holds on to heat, moderates our climate

3. How does the structure of a salt crystal change when it is dissolved in water. (use a diagram)



4. a) What will happen to the solubility of CO_2 when you put an open carbonated drink in the fridge.

-the solubility of a gas increases when the temperature goes down

b) What will happen to the solubility of salt if you heat up the water it's in.

- the solubility of a solid will increase when the temperature increases

5. Calculate the number of moles of Cl^- ions in 15.0 mL of 0.2 mol L^{-1} $AlCl_3$ solution in water.

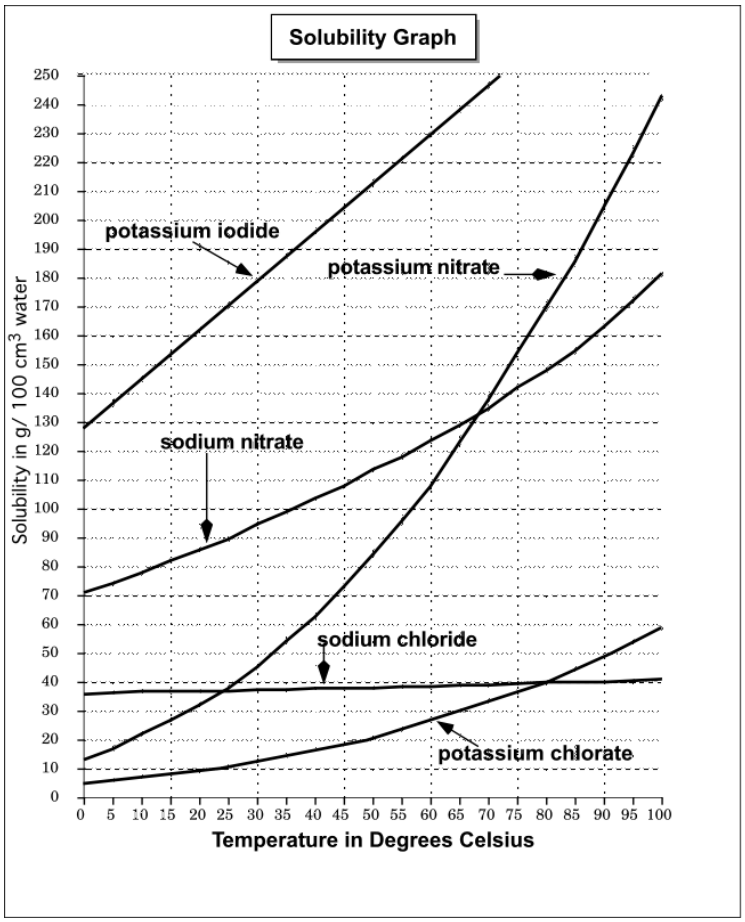
There are 0.009 mol Cl^- ions in 15.0 mL of the solution.

6. An aqueous solution of calcium chloride contains 2.00 g of calcium chloride (molar mass 110.98 g mol^{-1}) in 100.0 mL. Calculate the concentration of **chloride ion** (Cl^-) in the solution.

$[Cl^-] = 0.360$ mol L^{-1}

7. What volume of 0.200 mol L^{-1} Na_2CO_3 solution can be prepared from 21.20 g of Na_2CO_3 (molar mass = 106.0 g mol^{-1}).

A volume of 1.00 L of 0.200 mol L^{-1} Na_2CO_3 can be prepared.



8. Please refer to the diagram of solubility curves for the following questions.

a) What is the solubility of potassium iodide at 30ºC?

180g/100ml

b) What mass of NaCl is needed to prepare a saturated solution in 200g H_2O at 80 ºC?

$\frac{40g}{100ml} = \frac{x}{200ml}$ x = 80g

c) What is the lowest temperature at which 130g of sodium nitrate will completely dissolve in 100 g of H_2O? (1)

65ºC

d) What mass of potassium nitrate precipitates from solution if a saturated solution in 150g of water is cooled from 82ºC to 40 ºC? (3)

at 82ºC $\frac{175g}{100ml} = \frac{x\ g}{150ml}$ x = 263g

at 40 ºC $\frac{60g}{100ml} = \frac{x\ g}{150ml}$ x = 90g

263g - 90g = 173g

9. Describe two differences between a saturated and supersaturated solution.

- saturated has the maximum amount at a given temperature, supersaturated has more
- if you add a crystal to a supersaturated solution it crystals will precipitate out
- you need to heat then cool a solution to make a supersaturated solution

10. Describe how to make a 100 mL solution of 0.2 M potassium nitrate. Full marks will not be awarded without a concluding statement.

C x V = mol == 0.10L x 0.2M = 0.02 mol of KNO_3 0.02mol x 101.11g/mol = 2.02g

a) mass out 2.02 grams of potassium nitrate b) dissolve 2.02g of your solid in less tahn100mL
c) transfer the solution to a volumetric flask d) add water till the flask reached the fixed mark.
e) mix until all of the solid is dissolved

11. What volume of water will you need of 12.4M stock solution HCl to prepare a 1.0 L solution with a concentration of 5.00 M.

$C_1 \times V_1 = C_2 \times V_2$ 12.4M x V_1 = 5.00M x 1.0L V_1 = 0.4 L

Organic Chemistry

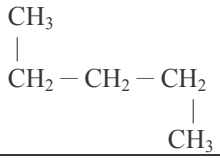
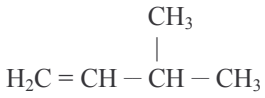
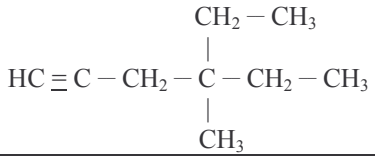
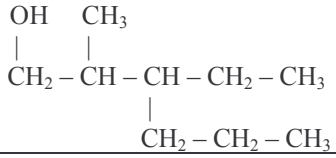
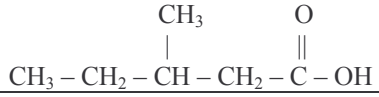
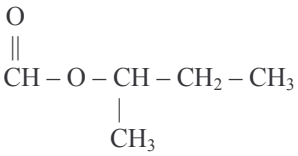
1. What is the purpose of a fractionating column and how does it work?

A Fractionating column is used to separate a mixture into its component parts by differences in boiling points. The fractionating column is filled with beads that allow for condensation. The bottom of the flask is heated and the gaseous vapours rise in the column. As vapours travel up the column they are cooled. The components with the lowest boiling temperatures travel the furthest up the column. Vapours with higher boiling points condense lower in the column allowing for a separation by boiling temperature.

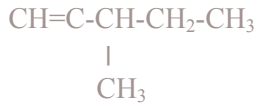
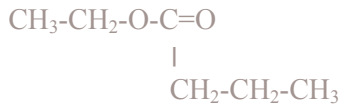
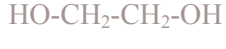
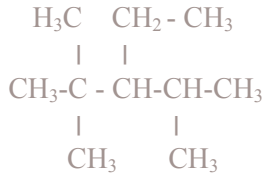
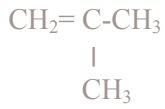
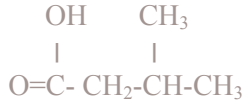
2. What is the difference between an organic compound and a molecular compound?

An organic compound is a compound that contains carbon. (exceptions include: carbon dioxide, carbon monoxide, and carbonates.) A molecular compound is made up of two or more non-metals.

3. Name the following compounds and identify each as an alkane, alkene, alkyne, alcohol, a carboxylic acid, or an ester.

	Structural Formula	IUPAC Name	Type of Compound
a.		pentane	alkane
b.		3-methyl-1-butene	alkene
c.		4-ethyl-4-methyl-1-hexyne	alkyne
d.		3-ethly-2-methyl-1-hexanol	alcohol
e.		3-methyl-pentanoic acid	carboxylic acid
f.		1-methylpropyl-methanoate	ester

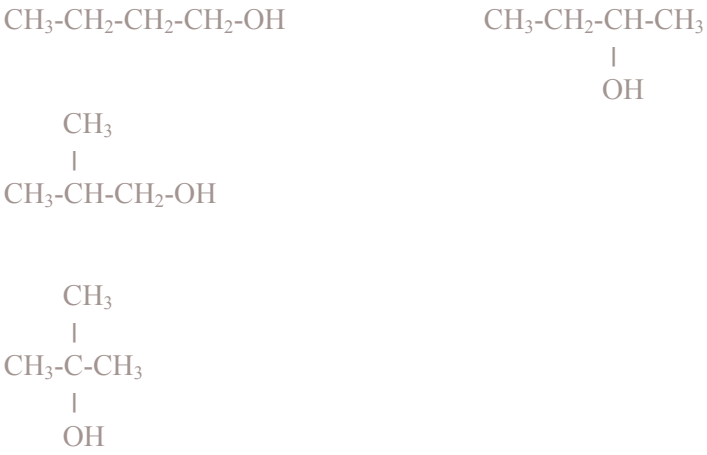
4. Draw the structural formulas for each of the following compounds.

a. 3 – methyl – 1 – pentyne	
b. Ethyl butanoate	
c. 1, 2 – ethanediol	
d. 2, 2, 4 – trimethyl – 3 – ethyl pentane	
e. 2 – methyl – 1 – propene	
f. 3 – methyl butanoic acid	

5. Identify the type of organic molecule from its chemical formula. Select from alkanes, alkenes, alkynes, alcohols, carboxylic acids, and esters.

Chemical Formula	Type of Compound	Chemical Formula	Type of Compound
a. CH_4	Alkane	b. CH_3COOH	Carboxylic acid
c. C_4H_8	Alkene	d. $C_3H_7COOCH_3$	Ester
e. C_2H_5OH	Alcohol	f. C_6H_{12}	Alkene

6. Sketch and name 4 isomers of C_4H_9OH.



7. How does CH_3OH differ from NaOH?

Methanol is an organic compound sodium hydroxide is an inorganic compound. Methanol is an alcohol while sodium hydroxide is an ionic compound. NaOH disassociates in water forming Na^+ and OH^- ions.

8. What is a characteristic property of:
   a. an alcohol

Alcohols generally have low boiling temperatures. Alcohols have distinct sweet odours.

   b. a carboxylic acid

Carboxylic acids will react with alcohols to produce esters and generally have pungent and offensive odours.

   c. an ester

Esters have strong fruity odours and are created by combining a carboxylic acid with an ester in the presence of an acid catalyst.

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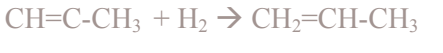
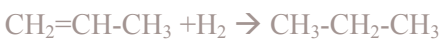
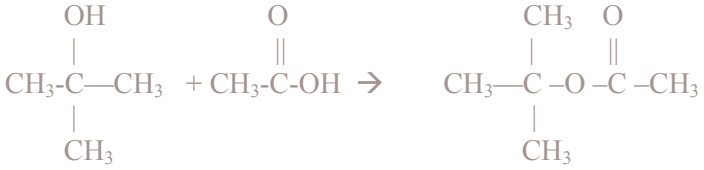
9. Draw the structural formulas for all reactants and products for the hydrolysis of propyne with 2 moles of hydrogen gas in the presence of a platinum catalyst.

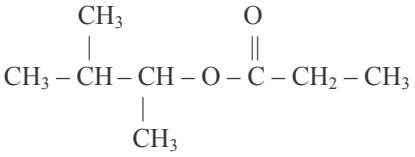




10. Sketch the structural formulas of all chemical species AND name the ester product in the esterification reaction of 2 – methyl – 2 – propanol and ethanoic acid.



11. The ester represented by the following formula may be synthesized from



3 – methyl – 2 – butanol and propanoic acid in the presence of a sulfuric acid catalyst

12. Decene is cracked catalytically forming two alkane molecules. One of the products is octane.
    a. Draw the structural formula and name the second product.

$CH_3 – CH_3$, ethane

    b. What other reactant must be present to obtain a balanced chemical equation?

Two molecules of hydrogen gas

13. Write the balanced chemical equations for all reactants and products involved in the combustion of heptanol.

$2\ C_7H_{15}OH + 21\ O_2 \rightarrow 14\ CO_2 + 16\ H_2O$