110pts possible

MHS 2015 Tryout

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if pg 1 is used. Pg 1 should help differentiate 9th graders if any are tried.

I. THE ATOM

Note: If you've learned any quantum mechanics, forget about it for a while. ***Think grade 9 level chem.***

Components of an atom: Electron
Neutron
Proton

1) Which component carries a positive charge? proton

2) Which component carries a negative charge? electron

3) Which component does not have mass? electron

4) Which component is not in the nucleus? electron

5) Complete the table:

each row is all or nothing

Atomic #	Element Name	Atomic Symbol	# of protons	# of neutrons	~~Atomic mass~~ mass #
6	Carbon	C	6	6	12
8	Oxygen	O	8	8	16
17	Chlorine	Cl	17	18	35

6) Sodium chloride (table salt) is composed of two atoms, sodium and chlorine atoms. This means that sodium chloride is an... (circle answer)

A) element B) compound C) solution D) isotope E) ion

7) When an atom has lost or gained an electron it no longer has a neutral charge. The type of atom which carries either electrical charge is called an... (circle answer)

A) element B) compound C) solution D) isotope E) ion

8) The atomic mass listed in the periodic table is not an integer (a whole number). It is a decimal number. Why?

It is an average based upon the natural abundance of the different isotopes of an element.

10pts

II. CHEMISTRY SKILLS

10pts (2 each) Balance the following reactions:

1) 2 $H_{2(g)}$ + ___ $O_{2(g)}$ → 2 $H_2O_{(l)}$

2) ___ Li_3N + 3 KCl → 3 LiCl + ___ K_3N

3) 3 H_2 + ___ N_2 → 2 NH_3

4) 2 Al + 3 Br_2 → 2 $AlBr_3$

5) ___ $C_3H_{8(g)}$ + 5 $O_{2(g)}$ → 3 $CO_{2(g)}$ + 4 $H_2O_{(l)}$

10pts (1 each) 6) Complete the following table:

Chemical Name	Chemical Formula
Sodium Chloride	NaCl
Lithium Hydride	LiH
Calcium Carbonate	$CaCO_3$
Ammonium Nitrate	NH_4NO_3
Hypochlorous Acid	HClO
Magnesium Fluoride	MgF_2
Carbon Dioxide	CO_2
Copper (IV) Oxide	CuO_2
Tetraphosphorus Decoxide	P_4O_{10}
Sulfurous Acid	H_2SO_3

3pts 7) Copper (II) Oxide will decompose when it is heated strongly.

$4\ CuO_{(s)} \rightarrow 2\ Cu_2O_{(s)} + O_{2(g)}$

How many grams of oxygen can be obtained from 2.64 g $CuO_{(s)}$?

1: answer (value)
1: all three conversions shown/justified
1: correct label and sig figs

$$2.64\text{g CuO} \times \frac{1\text{mol CuO}}{79.55\text{g CuO}} \times \frac{1\text{mol O}_2}{4\text{mol CuO}} \times \frac{32.00\text{g O}_2}{1\text{mol O}_2} = \boxed{0.265\text{g O}_2}$$

7pts **8.) 100. kg of glass (SiO_2) are reacted with excess carbon to produce 57.4kg silicon carbide (SiC). What is the % yield of silicon carbide? (7pts)**

$SiO_{2\,(s)} + 3C_{(s)} \rightarrow SiC_{(s)} + 2\ CO_{(g)}$

Theoretical Yield

2: theoretical work shown
2: theoretical value

$$100\text{ kg SiO}_2 \times \frac{1{,}000\text{g SiO}_2}{\text{kg SiO}_2} \times \frac{1\text{mol SiO}_2}{60.1\text{g SiO}_2} \times \frac{1\text{mol SiC}}{1\text{mol SiO}_2} \times \frac{40.1\text{g SiC}}{1\text{mol SiC}} \times \frac{\text{kg SiC}}{1{,}000\text{g SiC}} = \underline{66.7\text{ kg SiC}}$$

Actual Yield = 57.4kg SiC

$$\%\text{ yield} = \frac{57.4\text{ kg SiC}}{66.73\text{ kg SiC}} = \boxed{83.1\%}$$

2
2: final value
1: correct sig figs

30 pts

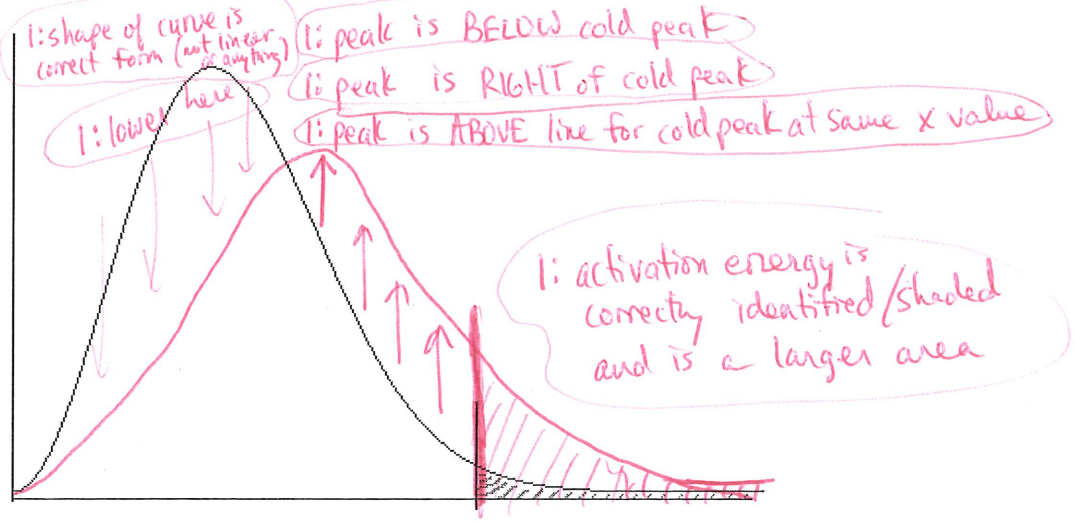
III. Chemical Kinetics

A reaction is activated by a teacher inside the glow sticks he is using. The reaction gives off energy in the form of light. One glow stick is exposed to a cold environment, the other a warmer environment.

1 pts 1. In which environment is the reaction occurring more quickly? WARMER

2. If this Maxwell-Boltzmann distribution represents the reacting molecules in the cold glow stick, draw a rough Maxwell-Boltzmann distribution representing the warm glow stick on the same graph below (write directly OVER the current graph, adding a 2nd line/area).

7 pts



3) Given the following experimental data, find the rate law and the rate constant for the reaction:

$$NO\ (g) + NO_2\ (g) + O_2\ (g) \rightarrow N_2O_5\ (g)$$

Run	$[NO]_o$, M	$[NO_2]_o$, M	$[O_2]_o$, M	Initial Rate, Ms^{-1}
1	0.10 M	0.10 M	0.10 M	2.1×10^{-2}
2	0.20 M	0.10 M	0.10 M	4.2×10^{-2}
3	0.20 M	0.30 M	0.20 M	1.26×10^{-1}
4	0.10 M	0.10 M	0.20 M	2.1×10^{-2}

6pts

Rate = $k[NO][NO_2]$

$0.021\ mol\ L^{-1}\ s^{-1} = k\,(0.10\ mol\ L^{-1})(0.10\ mol\ L^{-1})$

$k = 2.1\ L\ mol^{-1} s^{-1}$

$$-\frac{d[NO]}{dt} = 2.1\ L \cdot mol^{-1} \cdot s^{-1}\,[NO][NO_2]$$

6pts 4) When the proper molecules collide for a reaction to take place, that reaction does not always happen. Name 2 reasons why a reaction may not occur even when reactants collide.

1.) IMPROPER ORIENTATION

2.) low TEMPERATURE
insufficient ENERGY
does not meet ACTIVATION ENERGY

These are all the SAME reason.

20 pts

5pts

5. At 25°C the rate constant for a first order reaction is $2.0 \times 10^3\ s^{-1}$. The activation energy is 15.0kJ per mole. What is the rate constant at 75°C? ($R = 8.31\ J\ K^{-1}\ mol^{-1}$)

$$\ln \frac{k_2}{k_1} = \frac{-E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

k_2 = answer $\quad T_2 = 348K \quad E_a = 15.0\ kJ/mol$

$k_1 = 2.0 \times 10^3 s^{-1} \quad T_1 = 298K \quad R = 8.31\ J\ K^{-1} mol^{-1}$

$\hookrightarrow .00831\ kJ\ K^{-1} mol^{-1}$

$$\ln \frac{k_2}{2.0\times10^3 s^{-1}} = \frac{-15.0\ kJ\ mol^{-1}}{.00831\ kJ\ K^{-1} mol^{-1}}\left(\frac{1}{348K} - \frac{1}{298K}\right)$$

$k_2 = 4.8 \times 10^3 s^{-1}$

4pts

6) The mechanism of a reaction is shown below.

1: equation
2: value
1: unit
1: sig figs

a) What is the overall reaction?
b) Which compounds are intermediates?
c) Predict the rate law based on this mechanism.
d) What is the overall order of the reaction?

$HOOH + I^- \rightarrow HOI + OH^-$ (slow)
$HOI + I^- \rightarrow I_2 + OH^-$ (fast)
$2OH^- + 2H_3O^+ \rightarrow 4\ H_2O$ (fast)

1 (a) $HOOH + 2I^- + 2H_3O^+ \longrightarrow I_2 + 4H_2O$

1 (b) HOI, OH^-

1 (c) RATE = $k[HOOH][I^-]$

1 (D) 2ND ORDER

11pts

7) Derive the rate law that is consistent with the proposed mechanism in the formation of phosgene from Cl2 and CO. Solve for the rate constant in terms of k1, k2, and k3. What is the order of the reaction?

i. $Cl_2 + M = 2\ Cl + M$ (fast equilibrium, K_1)
ii. $Cl + CO + M \rightleftharpoons ClCO + M$ (fast equilibrium, K_2)
iii. $ClCO + Cl_2 \rightarrow Cl_2CO + Cl$ (slow, k_3)

The overall reaction is: $Cl_2 + CO = Cl_2CO$

Rate = $k[ClCO][Cl_2]$

$[ClCO] = [Cl][CO]$

$[Cl] = [Cl_2]^{1/2}$

Rate = $k[Cl_2]^{3/2}[CO]$ (4)

Rate = $k_3[ClCO][Cl_2]$

$[ClCO] = k_2[Cl][CO]$

$[Cl] = k_1^{1/2}[Cl_2]^{1/2}$

Rate = $k[CO][Cl]^{3/2}$

where $k = k_3 k_1^{(1/2)} k_2$ (4)

The overall order of the reaction is 2.5. (3)

20pts

IV. Reactions – Write net ionic equations matching the following descriptions.

1. Hydrochloric acid solution is treated with rubidium hydroxide solution.
2. Pentane (C_5H_{12}) is burned completely in excess oxygen gas.
3. A sample of solid iron(III) oxide is reduced completely with solid carbon.
4. Hydrazine (N_2H_4) is burned in a limited oxygen environment.
5. Equal volumes of equimolar sodium hydroxide and sulfuric acid are combined.
6. Nitric acid solution is dropped onto zinc ribbon.
7. Sodium oxide shavings are added to distilled water.
8. A solution containing silver(I) ion (an oxidizing agent) is mixed with a solution containing iron(II) ion (a reducing agent).
9. Bromine gas is bubbled into a solution of sodium iodide.
10. Phosphorus pentabromide is added to water.

1pt reactants
1pt products
1pt all correct AND balanced

(1) $H^+ + OH^- \rightarrow H_2O$

(2) $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$

(3) $2Fe_2O_3 + 3C \rightarrow 3CO_2 + 4Fe$

(4) $N_2H_4 + 2O_2 \rightarrow 2NO + 2H_2O$

(5) $H_2SO_4 + OH^- \rightarrow HSO_4^- + H_2O$ OR $H^+ + OH^- \rightarrow H_2O$

(6) $2H^+ + Zn \rightarrow H_2 + Zn^{2+}$

(7) $Na_2O + H_2O \rightarrow 2Na^+ + 2OH^-$

(8) $Ag^+ + Fe^{2+} \rightarrow Ag + Fe^{3+}$

(9) $Br_2 + 2I^- \rightarrow 2Br^- + I_2$

(10) $PBr_5 + 4H_2O \rightarrow H_3PO_4 + 5H^+ + 5Br^-$

30pts