Name________________

CH1020

EXAM 3A (70 points)

November 30th, 2018

There are a total of 11 pages in the exam (including this page).
There are a total of 13 questions.
Show your work to get full credit.
The required tables can be found on the last 4 pages

Name Solution A

1. (2 points) Which of the following statements correctly describes the signs of q and w for the following process at P = 1 atm and T = 25°C ?

$$CO_2(s) \rightarrow CO_2(g)$$

   a. q and w are negative

   [✓ b.] q is positive, and w is negative

   c. q is negative and w is positive

   d. q and w are both positive

   e. q and w are both zero

2. (2 points) Indicate of each of the following processes is ***exothermic*** **or** ***endothermic***

   a. vaporization of liquid water (liquid water is the system) endothermic ①

   b. When solid ammonium nitrate is dissolved in water, the solution gets cold (ammonium nitrate is the system) endothermic ①

3. (2 points) For each of the following reactions, indicate whether the absolute value of ΔE is smaller, equal or larger than ΔH

   a. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ ΔE < ΔH ①

   b. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$ ΔE = ΔH ①

4. (2 points) 10.0 g of a metal, initially at 25°C, is placed into 10.0 g of water, initially at 100°C. Which metal will have the highest final temperature? Shown after each metal is its specific heat (you don't need to do a calculation to solve this question).

   a. silver (0.235 J/(g·°C))

   b. copper (0.385 J/(g·°C))

   c. iron (0.450 J/(g·°C))

   [✓ d] gold (0.128 J/(g·°C)) ②

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5. (5 points) To inflate a balloon pressure-volume work is done on the surroundings. If 250 J of work was used to inflate a balloon from an initial volume of 0.400 L against an external pressure of 1.00 atm, what is the final volume of the balloon?

$-250J \cdot \frac{1 atm \cdot L}{101.3J} = -2.47 atm \cdot L$ ①

$-2.47 atm \cdot L = -1.00 atm \cdot (V_f - 0.4L)$ ①

$1.00 atm \cdot V_f = 2.47 atm \cdot L + 0.400 atm \cdot L = 2.87 atm \cdot L$ ①

$V_f = 2.87L$ ②

6. (5 points) Use Hess's Law to calculate the enthalpy change for the reaction

$$CH_4(g) + 4Cl_2(g) \rightarrow CCl_4(g) + 4HCl(g)$$

from the following data:

$[C(s) + 2H_2(g) \rightarrow CH_4(g) \quad \Delta H = -74.6\,kJ/mol] \times (-1) = 74.6\,kJ/mol$ ①

$[C(s) + 2Cl_2(g) \rightarrow CCl_4(g) \quad \Delta H = -95.7\,kJ/mol] \times (1) = -95.7\,kJ/mol$ ①

$[H_2(g) + Cl_2(g) \rightarrow 2HCl(g) \quad \Delta H = -92.3\,kJ/mol] \times 2 = -184.6\,kJ/mol$ ①

(provide the appropriate chemical reactions to receive full credit)

$-205.7\,kJ/mol$ ②

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7. (8 points) Use ΔH^{o}_{f} values to calculate ΔH^{o}_{rxn} for the following reaction (see table for ΔH^{o}_{f} values, provide the appropriate chemical reactions to receive full credit).

$$SiO_2(s) + 4HCl(g) \rightarrow SiCl_4(l) + 2H_2O(l)$$

$[Si(s) + O_2(g) \rightarrow SiO_2(s)$ $\Delta H_f^\circ = -910.9$ kJ/mol$] \times (-1)$ (1.5)

$[\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow HCl(g)$ $\Delta H_f^\circ = -92.3$ kJ/mol$] \times (-4)$ (1.5)

$[Si(s) + 2Cl_2(g) \rightarrow SiCl_4$ $\Delta H_f^\circ = -687$ kJ/mol$] \times 1$ (1.5)

$[H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O$ $\Delta H_f^\circ = -285.8] \times 2$ (1.5)

$\Delta H_{rxn} = 910$ kJ/mol $+ 369.2$ kJ/mol $+ (-687$ kJ/mol$) + (-571.6$ kJ/mol$)$ ①

$\Delta H_{rxn} = +21.5$ kJ/mol ①

8. (8 points) A 55.0 g iron metal (specific heat capacity = 0.450 J/g °C) is heated to 90.0°C and dropped into 75.0 g of water at 23.2 °C (specific heat capacity = 4.184 J/g°C). What is the final temperature of the water/iron mixture?

$m_{Fe} \cdot C_s(Fe) \cdot \Delta T_{Fe} = -(m_{H_2O} \cdot C_s(H_2O) \cdot \Delta T_{H_2O})$ ①

$55g \cdot 0.450\ J/g°C\ \Delta T_{Fe} = -(75.0g \cdot 4.184\ J/g°C \cdot \Delta T_{H_2O})$ ①

$24.75\ J/°C\ \Delta T_{Fe} = -313.8\ J/°C\ \Delta T_{H_2O}$ ①

$\Delta T_{Fe} = -12.68\ \Delta T_{H_2O}$ ①

$T_f - 90.0°C = -12.68\ T_f + 294.1°C$ ①

$T_f + 12.68 T_f = 294.1°C + 90.0°C = 384.1$ ①

$T_f = \frac{384.1°C}{13.68} = 28.1°C$ ②

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9. (8 points) Zinc metal reacts with hydrochloric acid according to the balanced equation:

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

When 0.103g of Zn(s) is combined with enough HCl to make 50.0 mL of solution in a coffee cup calorimeter, all of the Zn reacts, raising the temperature of the solution from 22.5°C to 23.7°C. Find ΔH_{rxn} for this reaction as written ($d_{solution}$=1.00 g/ml; $C_{s,\ solution}$=4.18 J/g°C)

$$q = 50.0g \cdot 4.18\ J/g°C \cdot \underbrace{(23.7°C - 22.5°C)}_{1.2°C}$$ ②

$q = 250.8\ J$ ①

$q_{rxn} = -250.8J$ ①

$\#\ moles\ (Zn) = \frac{0.103g}{65.41\ g/mol} = 1.57 \cdot 10^{-3}\ mol$ ①

$\Delta H = \frac{-250.8J}{1.57 \cdot 10^{-3}\ mol}$ ① $= -1592700/mol \quad -159\ kJ/mol$ ②

10. (8 points) A bomb calorimeter has a heat capacity of 3.640 kJ/°C. When a 1.608 g sample of cymene ($C_{10}H_{14}$, found in several spices and fragrances including thyme, anise and coriander) was burned in this calorimeter, the temperature increased by 19.35°C. Calculate the energy of combustion for one mole of cymene.

$q = 3.640\ kJ/°C \cdot 19.35°C = 70.43\ kJ$ ②

$q_{rxn} = -70.43\ kJ$ ②

$\#moles\ (C_{10}H_{14}) = 1.608g \cdot \frac{1\ mol}{134.2} = 0.012\ mol$ ①

$\Delta H_{rxn} = \frac{-70.43kJ}{0.012\ mol}$ ① $= -5878\ kJ/mol$ ②

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11. (4 points) What mass of CH_4 must burn to emit 267 kJ of heat?

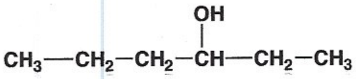
$$CH_4(g) + 2O_2(g) \rightarrow \overset{1}{\cancel{3}}CO_2(g) + 3H_2O(g) \quad \Delta H_{rxn} = -802.3\,kJ/mol$$

$$\Delta H_{rxn} = \frac{q_{rxn}}{\#moles} \Rightarrow -802.3\,kJ/mol = \frac{-267\,kJ}{\#moles} \quad ②$$

#moles (CH_4) = 0.333 mol ①

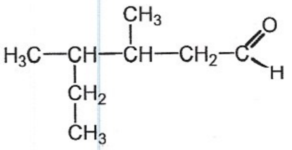
mass (CH_4) = 5.34 g ①

12. (8 points) Give the names for the following chemical compounds:

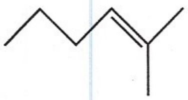
a) 

$CH_3-CH_2-CH_2-\overset{OH}{\overset{|}{CH}}-CH_2-CH_3$

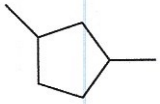
3-hexanol ②

b) 

3,4 dimethyl hexanal ②

c) 

2-methyl-2-hexene ②

d) 

1,3 dimethyl cyclo pentane ②

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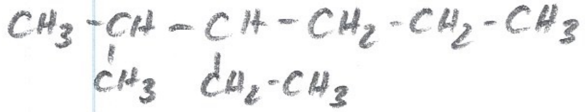
13. (8 points) Provide the condensed structural formula for the following compounds:

a. 3-hexene

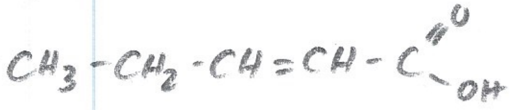
$CH_3-CH_2-CH=CH-CH_2-CH_3$ ②

b. 3-ethyl-2methyl hexane



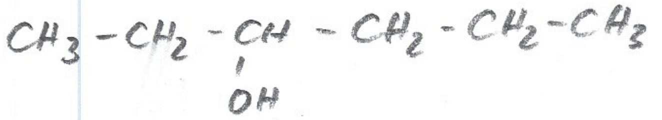
$CH_3-\underset{CH_3}{\underset{|}{CH}}-\underset{CH_2-CH_3}{\underset{|}{CH}}-CH_2-CH_2-CH_3$ ②

c. 2-pentenoic acid



$CH_3-CH_2-CH=CH-\overset{O}{\overset{\|}{C}}-OH$ ②

d. 3-hexanol



$CH_3-CH_2-\underset{OH}{\underset{|}{CH}}-CH_2-CH_2-CH_3$ ②

Name ____________________

Main groups

Main groups

☐ Metals ▨ Metalloids ☐ Nonmetals

Transition metals

	1A[a] 1	2A 2	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	9	10	1B 11	2B 12	3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1	1 **H** 1.008																	2 **He** 4.003
2	3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.64	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.96	43 **Tc** [98]	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
6	55 **Cs** 132.91	56 **Ba** 137.33	57 **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** [208.98]	85 **At** [209.99]	86 **Rn** [222.02]
7	87 **Fr** [223.02]	88 **Ra** [226.03]	89 **Ac** [227.03]	104 **Rf** [261.11]	105 **Db** [262.11]	106 **Sg** [266.12]	107 **Bh** [264.12]	108 **Hs** [269.13]	109 **Mt** [268.14]	110 **Ds** [271]	111 **Rg** [272]	112* [277]		114 [289]		116 [292]		

Lanthanide series	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** [145]	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
Actinide series	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** [237.05]	94 **Pu** [244.06]	95 **Am** [243.06]	96 **Cm** [247.07]	97 **Bk** [247.07]	98 **Cf** [251.08]	99 **Es** [252.08]	100 **Fm** [257.10]	101 **Md** [258.10]	102 **No** [259.10]	103 **Lr** [262.11]

[a] The labels on top (1A, 2A, etc.) are common American usage. The labels below these (1, 2, etc.) are those recommended by the International Union of Pure and Applied Chemistry.

The names and symbols for elements 112 and above have not yet been decided.

Atomic masses in brackets are the masses of the longest-lived or most important isotope of radioactive elements.

*Element 112 has a proposed name of Copernicium which is, at the time of this publication, under review by IUPAC.