SCH4U TEST – Unit 3: Energy & Rates of Reaction
Pierre Elliott Trudeau High School

TEACHER: Mr Cheung **NAME:** Uni Lee

TIME ALLOTED: 75 minutes **DATE:** Nov 25 2014

Knowledge	Communication	Thinking/Inquiry	Application
9 / 12	6 / 8	6 / 7	12 / 12

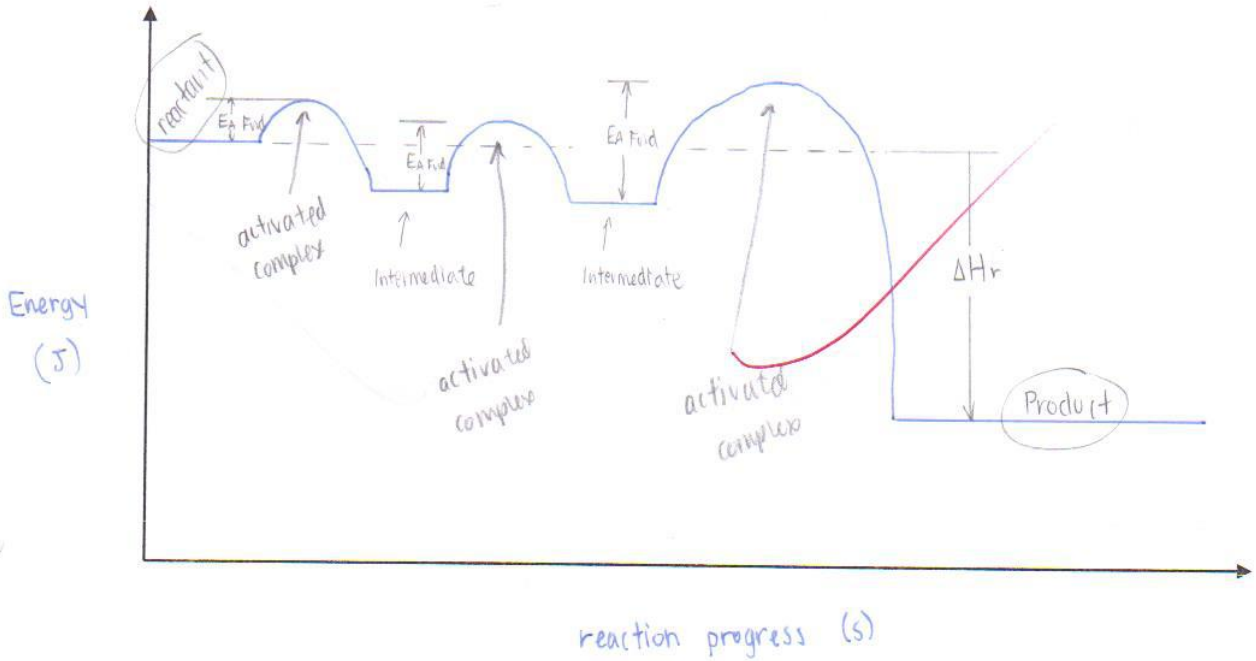
COMMUNICATION – *Short Answers & Diagrams. Answer each question in the space provided.* **(8 marks)**

13. Briefly describe THREE assumptions that are made when using a calorimeter (these assumptions greatly simplify our calculations). **(3 marks)**

When using a calorimeter, we assume that no energy is lost to the calorimeter, sound, or light. It is all to heat. And the air in it. We assume that the calorimeter is isolated. Heat doesn't enter or leave it. We assume the little bit of stirring we do doesn't add kinetic energy into the system. We assume everything in it fully reacted. The change in temperature is the change in energy

-2

14. An exothermic reaction is found to have THREE elementary steps, with the rate determining step being the THIRD one. Sketch (and properly label) a potential energy diagram for this reaction. Be sure to label your axis, reactants, products, ΔH_r , activation energies, intermediates, and activated complexes. **(5 marks)**



THINKING/INQUIRY – *Short Answers & Calculations. Show your work for full marks.* **(7 marks)**

15. Cyanic acid (HCN) reacts with hydrogen gas to produce methylamine (CH_3NH_2). Calculate the ΔH_r for this reaction using bond energies from your blue sheet. **(3 marks)**

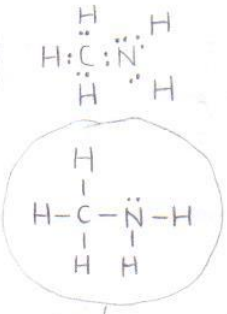
$HCN_{(aq)} + 2H_{2(g)} \longrightarrow CH_3NH_2$

H:C:::N: H-H H-H

H-C≡N:

H-C 413
C≡N 891

H-H 432
H-H 432



HC 413 CN 305
HC 413 NH 391
HC 413 NH 391

$\Delta H_r = [(413 \times 3) + 305 + (391 \times 2)] - [(432 \times 2) + 413 + 391]$

$= 2326 - 2168$

$= 158$ kJ/mol

-1

Therefore, the ΔH_r for this reaction is +158 kJ/mol

16. Nitrogen monoxide gas can be produced according to the following equation:

$$N_2O_{(g)} + NO_{2(g)} \rightarrow 3NO_{(g)}$$

Calculate the standard molar enthalpy of reaction($\Delta H°_r$) with respect to nitrogen monoxide using Hess' Law (rearranging the equations found in Table 1.1 at the back of the test) **(4 marks)**

$N_2O_{(g)} + NO_{2(g)} \longrightarrow 3NO_{(g)}$

	kJ/mol
a) $N_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow N_2O_{(g)}$	$\Delta H°_f = +82.05$
b) $\frac{1}{2}N_{2(g)} + O_{2(g)} \rightarrow NO_{2(g)}$	$\Delta H°_f = +34.00$
c) $\frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow NO_{(g)}$	$\Delta H°_f = +90.72$
-a) $N_2O_{(g)} \longrightarrow N_{2(g)} + \frac{1}{2}O_{2(g)}$	$\Delta H°_f = -82.05$
-b) $NO_{2(g)} \longrightarrow \frac{1}{2}N_{2(g)} + O_{2(g)}$	$\Delta H°_f = -34.00$
3c) $\frac{3}{2}N_{2(g)} + \frac{3}{2}O_{2(g)} \longrightarrow 3NO_{(g)}$	$\Delta H°_f = +272.16$

$\Delta H°_{f_{NO}} = \frac{(-82.05) + (-34.00) + (+272.16)}{3}$

$= \frac{+156.11 \text{ kJ}}{3 \text{ mol}}$

$= +52.03666...$ kJ/mol

$\doteq +52.04$ kJ/mol

(-a) + (-b) + (3c)

$= N_2O_{(g)} + NO_{2(g)} + \frac{3}{2}N_{2(g)} + \frac{3}{2}O_{2(g)} \longrightarrow N_{2(g)} + \frac{1}{2}O_{2(g)} + \frac{1}{2}N_{2(g)} + O_{2(g)} + 3NO_{(g)}$

$= N_2O_{(g)} + NO_{2(g)} + \frac{3}{2}N_{2(g)} + \frac{3}{2}O_{2(g)} \longrightarrow \frac{3}{2}N_{2(g)} + \frac{3}{2}O_{2(g)} + 3NO_{(g)}$

$= N_2O_{(g)} + NO_{2(g)} \longrightarrow 3NO_{(g)}$

Therefore, the standard molar enthalpy of reaction with respect to $NO_{(g)}$ is +52.04 kJ/mol.

APPLICATION – *Short Answers & Calculations. Show your work for full marks.* **(12 marks)**

17. The following data was collected for the reaction: $BrO_3^-{}_{(aq)} + 5\ Br^-{}_{(aq)} + 8\ H^+{}_{(aq)} \rightarrow 3\ Br_{2(l)} + H_2O_{(l)}$

Trial	$[BrO_3^-]$ mol/L	$[Br^-]$ mol/L	$[H^+]$ mol/L	Initial rate (mol L^{-1} s^{-1})
1	0.10	0.10	0.10	8.0×10^{-4}
2	0.20	0.10	0.10	1.6×10^{-3}
3	0.10	0.20	0.10	1.6×10^{-3}
4	0.10	0.10	0.20	3.2×10^{-3}
5	0.10	0.010	0.15	**(Z)**

a) Write the rate law expression for this reaction given the data above. **(3 marks)**

[Increase in $BrO_3^-]^x$ = rate
$2^x = 2$
$2^1 = 2$
rate order $[BrO_3^-] = 1$ → x

[Increase in $Br^-]^y$ = rate
$2^y = 2$
$2^1 = 2$
rate order $[Br^-] = 1$ → y

[increase in $H^+]^z$ = rate
$2^z = 4$
$2^2 = 4$
rate order $[H^+] = 2$ → z

$Rate = k[A]^x[B]^y[C]^z$
$= k[BrO_3^-]^1[Br^-]^1[H^+]^2$

Therefore, the rate law expression is $Rate = k[BrO_3^-]^1[Br^-]^1[H^+]^2$

b) What is the overall order for this reaction? **(1 mark)**

$1 + 1 + 2 = 4$

Therefore, the overall order of this reaction is 4.

c) What is the value of the rate constant (show proper units). **(2 marks)**

$K = ?$

$Rate = k[BrO_3^-]^1[Br^-]^1[H^+]^2$

sub in trial 2 → $0.0016 \frac{mol}{L \cdot s} = K\ [0.20\ mol/L]^1\ [0.10\ mol/L]^1\ [0.10\ mol/L]^2$

$0.0016 \frac{mol}{L \cdot s} = K\ (0.0002 \frac{mol^4}{L^4})$

$K = 0.0016 \frac{mol}{L \cdot s} \div 0.0002 \frac{mol^4}{L^4}$

$= 0.0016 \frac{mol}{L \cdot s} \times \frac{1\ L^3}{0.0002\ mol^3}$

$= 8 \frac{L^3}{mol^3 \cdot s}$

Therefore, the value of the rate constant is $8 \frac{L^3}{mol^3 \cdot s}$

d) Predict the reaction rate for trial #5. **(2 marks)**

$Z = ?$

$Rate = k[BrO_3^-]^1[Br^-]^1[H^+]^2$

$Z = (8 \frac{L^3}{mol^3 \cdot s}) \cdot [0.10\ mol/L]^1\ [0.010\ mol/L]^1\ [0.15\ mol/L]^2$

$= 0.00018 \frac{mol}{L \cdot s}$

$= 1.8 \times 10^{-4} \frac{mol}{L \cdot s}$

Therefore, the reaction rate for trial #5 is $1.8 \times 10^{-4} \frac{mol}{L \cdot s}$

18. 58.4 g of ethanol is burned in the presence of oxygen gas to produce gaseous water and carbon dioxide. If all this energy is used to heat 33.0 L of water, by how much will the water's temperature change?

$\Delta H°_C$ for ethanol is -1371 kJ/mol. Assume the density of water is 1g/mL **(4 marks)**

$$C_2H_6OH_{(l)} + O_{2(g)} \longrightarrow H_2O_{(g)} + CO_{2(g)}$$

$m_E = 58.4g$

$\Delta H_C = -1367\ kJ/mol$

$m_W = 33.0L = 33000mL = 33000g$

$C_W = 4.181\ J/g°C$

$T_i = 25°C$

$58.4g \div 47\frac{g}{mol} = 1.242553.\ mol$ of ethanol

$Q = 1.242553\ mol \times \left(-1367\frac{kJ}{mol}\right)$

$= -1698.570213...\ kJ$

$= -1698570.213...\ J$ ← lost

gain → $Q = m_W C_W \Delta T$

$1698570.213\ J = (33000g)(4.181\ J/g°C)(\Delta T)$

$\Delta T = \frac{1698570.213\ J}{33000g \cdot 4.181\ J/g°C}$

$= +12.31088...°C$

$\doteq 12.3°C$

Therefore, the temperature of the water will increase by about 12.3°C or K

KNOWLEDGE / UNDERSTANDING – *Multiple Choice. Choose the most appropriate answer and shade its corresponding letter on the Scantron sheet provided.* **(12 marks)**

1. When the products have a greater enthalpy than the reactants, the reaction is said to be:
   a. Exothermic
   b. Formative
   c. Endothermic
   d. Product favoured
   e. none of the above

2. Which of the following statements is true concerning ionic solids dissolving in water?
   a. Energy is released when the ionic bonds are disrupted
   b. Energy is released when ion-dipole attractions are formed
   c. Energy is released when the water molecule splits apart
   d. The solution must be heated up
   e. This is a chemical reaction

3. Which of the following statements concerning potential energy diagrams is true?
   a. In an exothermic reaction, the enthalpy of the products is higher than the reactants
   b. The height of the line represents the temperature of the reactants/products
   c. The difference between the products and reactants is known as the Activation Energy
   d. They cannot be used to determine if a reaction is exothermic or endothermic
   e. None of the above are true

4. A 3.25 g piece of gold is cooled from 20.5°C to 13.8°C. The specific heat capacity of gold is 0.129 J/g°C. How much heat is released?
   a. 2.81 J
   b. 2.80 J
   c. 2.8 J
   d. 5.78 J
   e. 8.59 J

   $Q = 3.25(0.129)(6.7)$
   $=$

5. How will doubling the mass affect the change in enthalpy?
   a. The enthalpy change remains constant.
   b. The enthalpy change doubles.
   c. Enthalpy change is reduced to half.
   d. ΔH stays the same
   e. Enthalpy becomes zero.

6. 52.0 g of acetylene gas, C_2H_2, is burned in oxygen. 4989 kJ of energy is released. Which thermochemical equation below best describes this reaction?
   a. $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O + 4989$ kJ
   b. $2C_2H_2 + 5O_2 + 4988$ kJ $\rightarrow 4CO_2 + 2H_2O$
   c. $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O + 2598$ kJ/mol
   d. $2C_2H_2 + 5O_2 + 2598$ kJ/mol $\rightarrow 4CO_2 + 2H_2O$
   e. $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$

3 $\frac{9}{3}$ $\frac{mol}{L \cdot s}$ 6

7. Given the following reaction: $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$
If the $[H_{2(g)}]$ decreases by 3 mol/L in 45 seconds, what is the corresponding rate of consumption for nitrogen?

a. 0.080 mol/L· s
(b.) 0.067 mol/L· s
c. 0.022 mol/L· s
d. 0.16 mol/L· s
e. 0.26 mol/L· s

8. The rate of a chemical reaction is doubled for every 10 °C rise in temperature. This is because of a(n)…

a. decrease in activation energy
b. increase in activation energy
c. increase in number of ineffective collisions
(d.) increase in the number of effective collisions
e. increase in enthalpy

9. The activation energy for a simple chemical reaction (A → B) is E_a. The activation energy for the reverse reaction

a. is the negative or opposite of E_a
(b.) can be less than or more than that of E_a
c. is always greater than that of E_a
d. is always less than that of E_a
e. is always half than that of E_a

10. $2A + B + C \rightarrow D$

If the rate law expression for the above reaction was found to be: Rate = $k[A]^2[B]$
What is the order of reaction with respect to C?

(a.) zero
b. first
c. second
d. third
e. *k*

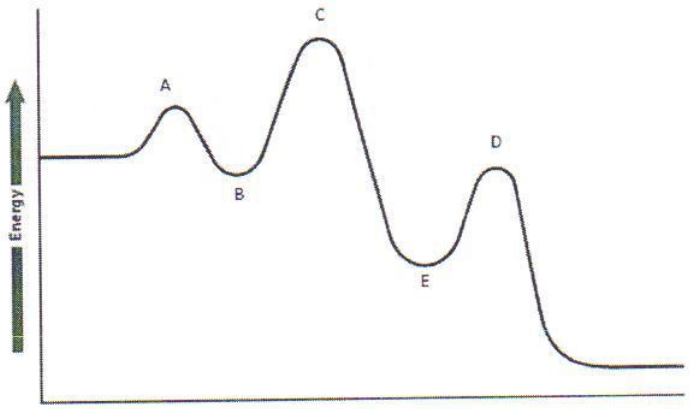
11. A reaction is found to be second order with respect to reactant A. What would be the effect on the rate if the concentration of A were doubled?

$[A]^2$ 8 64 16

a. The rate would double
(b.) The rate would quadruple
c. The rate would decrease by half
d. The rate would increase in an unpredictable way
e. The concentration of A has no effect on the rate

12. Which letters best represent the location of reaction intermediates?

a. A and B
b. C and E
(c.) B and E
d. A, C, and D
e. This reaction has no intermediates



PART 1

SUBJECTIVE SCORE INSTRUCTOR USE ONLY

100	90	80	70	60
50	40	30	20	10
9	8	7	6	5
4	3	2	1	0

IMPORTANT

USE NO. 2 PENCIL ONLY

- MAKE DARK MARKS
- ERASE COMPLETELY TO CHANGE
- EXAMPLE: A B ● D E

TO USE SUBJECTIVE SCORE FEATURE:

- Mark total possible subjective points
- Only one mark per line on key
- 163 points maximum

EXAMPLE OF STUDENT SCORE:

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SUBJECT	Chem	TEST NO.	
DATE	Nov 25.2014	PERIOD	2

TEST RECORD	
PART 1	
PART 2	
TOTAL	

(T) (F) KEY
% 2 3 5

	A	B	C	D	E	
1	A	B	●	D	E	
2	●	B	C	D	E	B
3	A	B	C	D	●	
4	●	B	C	D	E	
5	A	●	C	D	E	
6	A	B	●	D	E	A
7	A	●	C	D	E	C
8	A	B	C	●	E	
9	A	●	C	D	E	
10	●	B	C	D	E	
11	A	●	C	D	E	
12	A	B	●	D	E	
13	A	B	C	D	E	
14	A	B	C	D	E	
15	A	B	C	D	E	
16	A	B	C	D	E	
17	A	B	C	D	E	
18	A	B	C	D	E	
19	A	B	C	D	E	
20	A	B	C	D	E	
21	A	B	C	D	E	
22	A	B	C	D	E	
23	A	B	C	D	E	
24	A	B	C	D	E	
25	A	B	C	D	E	

09

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