Chemist: _____

November 2022 MAKEUP

Energy & Rates of Reactions

SCH4U1 UNIT 2 TEST 2 (A of L)

HAYNES **PERIOD 2**

Knowledge:	/10
Thinking & Investigation:	/8
Communication:	/10
Application	/10

KNOWLEDGE (10 marks)

Answer the following multiple choice questions by selecting the **BEST** answer for each question. Be sure to **record your selection in the table below** as only the Answer Grid will be evaluated.

MULTIPLE CHOICE ANSWER GRID

1.	A	B	C	(D)	3.	(A)	B	C	D	5.	A	(B)	C	D	
2.	A	B	C	(D)	4.	A	B	C	(D)						

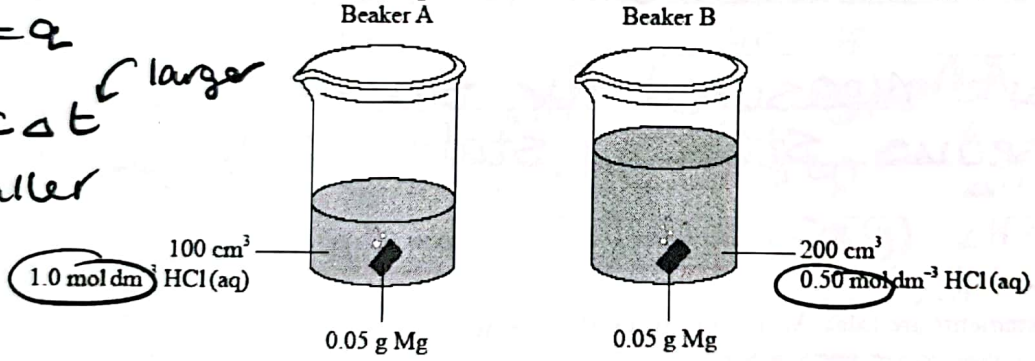
1. When determining the energy evolved from the combustion of a peanut, the temperature of 200.0 g of water in a calorimeter **increased from by 10.0 °C. If 200.0 g of olive oil were used instead of water** ($c_{olive\ oil}$ = 1.97 J g^{-1} K^{-1}), which of the following would be true for the same reaction?

A. Because it is a dilute solution, the olive oil would have the same density and specific heat capacity as water
B. The temperature change of the olive oil would be negative
C. The temperature change of the olive oil would be less than 10.0 °C
(D.) The temperature change of the olive oil would be greater than 10.0 °C ✓

mcat
c↓ ∴ Δt ↑

2. **Identical pieces of magnesium** are added to two beakers, A and B, containing **hydrochloric acid.** Both acids have the **same initial temperature** but their **volumes and concentrations differ.**

q = q
mcΔt
↑ smaller
larger



Assuming the **reaction of Mg with HCl is exothermic,** which statement is correct?

A. The maximum temperature in A and B will be equal and mass of Mg will decrease more slowly in B.
B. The maximum temperature in B will be higher than in A and the mass will decrease at the same rate.
C. The maximum temperature in A will be higher than in B and mass of Mg will decrease at the same rate.
(D.) The maximum temperature in A will be higher than B and mass of Mg will decrease more quickly in A.

3. The following equation shows the decomposition of calcium oxide to calcium metal.

$$2CaO(s) \rightarrow 2Ca(s) + O_2(g) \quad \Delta H° = +1004kJ$$

Which statement is **correct** for this reaction?

(A.) 502 kJ of energy are absorbed for every mol of calcium formed.
B. Equal energy is absorbed for every mol of oxygen gas and calcium reacted.
C. 502 kJ of energy are released for every mol of calcium oxide decomposed
D. 1004 kJ of energy are released for every mol of calcium formed.

THINKING **(8 marks)**

8. The enthalpy of **solution of ammonium nitrate** is + 75.1 kJ/mol NH_4NO_3.

a) Write the **thermochemical equation** for this process. [1 mark]

accept $NH_4NO_3(aq)$

$NH_4NO_3(s) + 75.1\,kJ \rightarrow NH_4^+(aq) + NO_3^-(aq)$

b) **State, with a reason,** whether the **final temperature of the surroundings will be higher or lower** than the initial temperature when this process takes place. [2 marks]

lower - kinetic energy from the surroundings is turned into potential energy in the system (since the reaction is endothermic

9. Use the equations provided to find the enthalpy change associated with the reaction below.

$$10\ Cl_3PO_{(g)} \rightarrow P_4O_{10(g)} + 6\ PCl_{5(g)}$$

1)	$\frac{1}{4}\ P_{4(s)} + \frac{3}{2}\ Cl_{2(g)} \rightarrow PCl_{3(g)}$	$\Delta H° = -306.4$ kJ
2)	$P_{4(s)} + 5\ O_{2(g)} \rightarrow P_4O_{10(g)}$	$\Delta H° = -2968$ kJ
3)	$PCl_{3(g)} + Cl_{2(g)} \rightarrow PCl_{5(g)}$	$\Delta H° = -84.2$ kJ
4)	$PCl_{3(g)} + \frac{1}{2}\ O_{2(g)} \rightarrow Cl_3PO_{(g)}$	$\Delta H° = -285.7$ kJ

1 x (2) $P_4(s) + 5O_2(g) \rightarrow P_4O_{10}(g)$ 3 marks $\Delta H = -2968$

6 x (3) $6PCl_3(g) + 6Cl_2(g) \rightarrow 6PCl_5(g)$ $\Delta H = 6(-84.2)$

-10 x (4) $10Cl_3PO(g) \rightarrow 10PCl_3 + 5O_2(g)$ $\Delta H = (-10)(-285.7)$

-4 x (1) $4PCl_3 \rightarrow P_4(s) + 6Cl_2(g)$ $\Delta H = -4(-306.4)$

[5 marks]

$P_4(s) + 5O_2(g) + 6PCl_3(g) + 6Cl_2(g) \rightarrow P_4O_{10}(g) + 6PCl_5(g) + 10PCl_3(g)$

$+ 10Cl_3PO(g) + 4PCl_3(g) \qquad + 5O_2(g) + P_4(s) + 6Cl_2(g)$

$10Cl_3PO(g) \rightarrow P_4O_{10}(g) + 6PCl_5(g)$ ✓ ✓ 1 mark

$\Delta H = +609.4$ kJ ✓ 1 mark sf to units (-2968)

$\Delta H = +609$ kJ

4. For which of the following is the **sign** of the enthalpy change **different** from the other three?

A. $CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$ decomposition +

B. $Na_{(g)} \rightarrow Na^{+}_{(g)} + e^{-}$ ionization +

C. $CO_{2(s)} \rightarrow CO_{2(g)}$ s → g +

(D.) $2Cl_{(g)} \rightarrow Cl_{2(g)}$ g → s −

5. Which of the following represents the **bond enthalpy** for the Si–F bond in silicon tetrafluoride (SiF_4)?

(A.) $SiF_{4\,(g)} \rightarrow 2\,F_{2\,(g)} + Si_{(s)}$

(B.) $SiF_{4\,(g)} \rightarrow SiF_{3(g)} + F_{(g)}$

C. $SiF_{4\,(g)} \rightarrow 4F_{(g)} + Si_{(g)}$

D. $SiF_{4\,(g)} \rightarrow 2\,F_{2\,(g)} + Si_{(g)}$

KNOWLEDGE CONTINUED

6. The enthalpy change for a chemical reaction can be calculated in various ways. One way is to bond enthalpies and another is to use standard enthalpies of formation. State **whether the bond enthalpy method will give a more or less accurate value than standard enthalpies of formation** for ΔH for the reaction and give **two reasons** for your choice.

[3 marks]

bond enthalpies are less accurate

✓ - average of one bond in many compounds (molecular environment is not considered)

✓- are measured for substances in gaseous state (state changes ignored)

7. The following statements are **false. Write a corrected statement** below each one (*yes, there may be more than one way to make each statement correct, and more than one correction to make in the statement!).* [2 marks]

a) Enthalpy of formation is the energy required or released to form an element directly from atoms in the gaseous state.

a substance ... elements ... standard state or other corrections that make the sentence correct

b) Specific heat capacity is a measure of the heat energy absorbed or released by a substance undergoing a state change. It can have units of J/g•°C.

latent heat

units of J/°C

14. When ice (straight out of the freezer at -15°C) is put into a drink the drink gets colder. The drink starts to change temperature right away, but the ice does not melt immediately.

Use your knowledge of thermochemistry to explain **why the ice does not start to melt immediately,** and **when it will start** to melt. [2 marks]

first the ice must increase to temp. 0°C to melt. (kinetic energy from the drink transfers to the ice to raise the temp)

At 0°C ice, instead of temperature continuing to change, kinetic energy of ice will be used to break hydrogen bonds between water molecules allowing the ice to melt.

Space for rough work, continuations or corrections

APPLICATION (10 marks)

12. A calorimetry experiment was carried out to determine the **molar enthalpy of solution** of lithium chloride. 16.960g of lithium chloride (LiCl) was added to a calorimeter containing 125.00 mL of water. The results of the experiment are shown below:

Calculate the **molar enthalpy of solution** of lithium chloride.

$\Delta T = 11 - 40 = -29°C$ ✓ $T_i = 40°C$

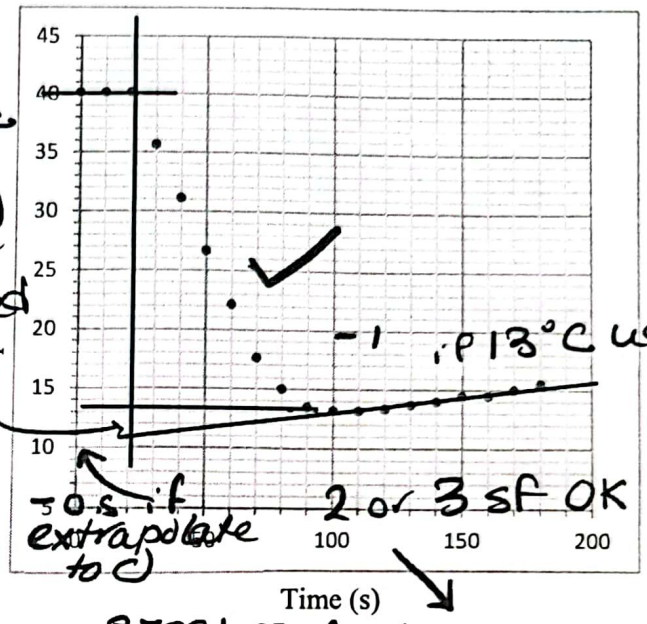
$q = mc\Delta t$

$q = (125.0g)(4.18 J/g·°C)(-29°C)$

$q = -15152.5\ J$

$\Delta H = -q$

$\Delta H = +15152.5\ J$



Corrected $T_f = 11.5$

-1 if 13°C used

-0.5 if extrapolate to 0

2 or 3 sf OK

$n = 16.960g \times \frac{1\ mol\ LiCl}{42.39g} = 0.400\ mol$ ✓

$\frac{15152.5}{0.400\ mol} = 37881.25\ J/mol$ ✓

$3.8 \times 10^4\ J/mol$ or $38\ kJ/mol$ LiCl

[4 marks]

13. Using the bond enthalpy values, provided on your data sheet, determine the **standard molar enthalpy of combustion** for **butane.**

$2C_4H_{10(g)} + 13O_{2(g)} \rightarrow 8CO_{2(g)} + 10H_2O_{(l)}$

$\frac{1}{2}$ $\frac{1}{4}$ $\frac{1}{5}$

✓0.5 final answer ← or ÷ by 2

break	✓ kJ	form	kJ
3 C-C	3(347kJ)	8 C=O	8(746)
10 C-H	10(413kJ)	10 O-H	10(464)
$\frac{1}{2}$ O=O	$\frac{13}{2}$(498)		
	8408 kJ ✓0.5		✓0.5 10608 kJ

$\Delta H = -2200.0$ ✓ dec places sf

$\Delta H = -2.200 \times 10^3\ kJ/mol\ C_4H_{10}$ (0.5)

[4 marks]

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COMMUNICATION (10 marks)

Overall form (units, significant figures, showing work etc.) throughout test _____ [2 marks]

10. a) Write the **formation equation** for heptane (C_7H_{16}) [1 mark]

$7C(s) + 8H_2(g) \rightarrow C_7H_{16}(l)$ state not important here

b) **Predict and explain** a value for the (molar) **enthalpy change** (ΔH_f°) for the formation of chlorine gas.

$Cl_2(g) \rightarrow Cl_2(g)$ enthalpy of formation of an element in its standard state is 0 (no change!)

[2 marks]

11. The **reaction** of $(CH_3)_3CBr_{(aq)}$ with $OH^-_{(aq)}$ is shown below

$$(CH_3)_3CBr_{(aq)} + OH^-_{(aq)} \rightarrow (CH_3)_3COH_{(aq)} + Br^-_{(aq)} + \text{energy}$$

The **mechanism** of the reaction is shown below:

Elementary Step

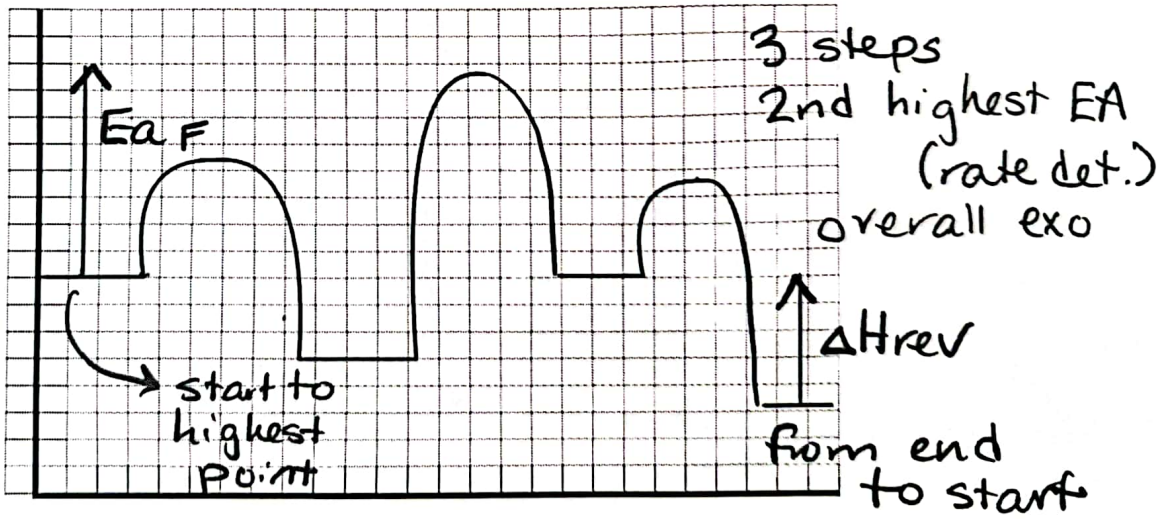
$(CH_3)_3CBr_{(aq)} \rightarrow (CH_3)_3C^+_{(aq)} + Br^-_{(aq)}$

$(CH_3)_3C^+_{(aq)} + H_2O_{(l)} \rightarrow (CH_3)_3COH_2^+{}_{(aq)}$

$(CH_3)_3COH_2^+{}_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)} + (CH_3)_3COH_{(aq)}$

It is known that the second step is the **rate-determining step**.

a) Sketch an energy profile for this reaction – <u>you do NOT need to label all the substances involved</u>. [3 marks]



Reaction Progress

b) On your graph **label**

i) The **overall activation energy** for the forward reaction

ii) The **overall enthalpy change** for the reverse reaction [2 marks]