

# Energy & Rates of Reactions

SCH4U1 UNIT 2 TEST 2 (A of L)  
HAYNES

PERIOD 2

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

## KNOWLEDGE

(10 marks)

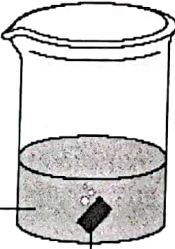
Answer the following multiple choice questions by selecting the **BEST** answer for each question. Be sure to record your selection in the table below as only the Answer Grid will be evaluated.

### MULTIPLE CHOICE ANSWER GRID

1. A <input checked="" type="radio"/> B <input type="radio"/> C <input type="radio"/> D	3. <input checked="" type="radio"/> A <input type="radio"/> B <input type="radio"/> C <input type="radio"/> D	5. <input checked="" type="radio"/> A <input type="radio"/> B <input type="radio"/> C <input type="radio"/> D
2. A <input type="radio"/> B <input checked="" type="radio"/> C <input type="radio"/> D	4. A <input type="radio"/> B <input checked="" type="radio"/> C <input type="radio"/> D	

- Carbonic acid, when dissolved in water, decomposes to carbon dioxide and water. A thermometer placed in the beaker showed a temperature change from 15 °C to 25 °C. **What can be deduced** from this observation?  
 A. Heat was transferred from the system to the surroundings and the reaction is endothermic.  
☒ B. Heat was transferred from the system to the surroundings and the reaction is exothermic.  
 C. Heat was transferred from the surroundings to the system and the reaction is endothermic.  
 D. Heat was transferred from the surroundings to the system and the reaction is exothermic.
- 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.

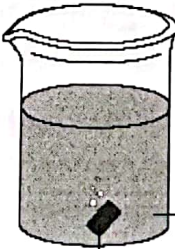
Beaker A



100ml 2.0 mol/L HCl(aq)

0.1g Mg

Beaker B

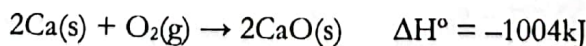


200ml 1.0 mol/L HCl(aq)

0.1g Mg

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

- The maximum temperature in A and B will be equal and mass of Mg will decrease more slowly in 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 B and mass of Mg will decrease more quickly in A.
- The maximum temperature in A will be higher than in B and mass of Mg will decrease at the same rate.
- The following equation shows the formation of calcium oxide from calcium metal.



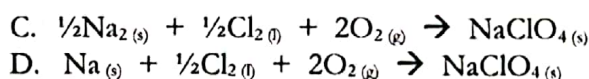
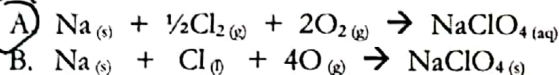
Which statement is correct for this reaction?

- ☒ A. 502 kJ of energy are released for every mol of calcium reacted.
- Equal energy is released for every mol of oxygen gas and calcium reacted.
  - 502 kJ of energy are absorbed for every mol of calcium oxide formed
  - 1004 kJ of energy are released for every mol of calcium reacted.

4. Which of the following processes is ~~never~~ <sup>endo</sup> ~~exothermic~~?

- A. Vaporization  $l \rightarrow g$  ✓  
 B. Freezing  $l \rightarrow s$  ✓  
 C. Dissolving (Solvation) *either*  
 D. Two of the above are never endothermic.

5. Which of the following represents the **standard enthalpy of formation** ( $\Delta H_f^\circ$ ) of sodium chlorate ( $\text{NaClO}_4$ )?



### KNOWLEDGE CONTINUED

6. State 3 assumptions that are made for the purposes of doing calorimetry calculations [3 marks]

- all energy from system (rxn) transferred to <sup>from</sup> surroundings (water)
- no energy absorbed/released to/from calorimeter
- no energy transferred from/to calorimeter to/from external surroundings
- density and specific heat capacity of a dilute, aqueous solution are equal to water

✓ 1 each, any 3

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.

enthalpy of formation is energy required or released to form a substance directly from its elements in their standard states ✓

- b) Object A and B are to be cooled from  $30^\circ\text{C}$  to  $10^\circ\text{C}$ . If both objects are the same volume, but A has a lower specific heat capacity than B, it will require ~~more energy~~ <sup>less energy</sup> to lower the temperature of A than B.

... If both objects have the same mass ✓  
but A has a higher specific heat capacity than B...

other corrections that make the sentences correct OK.



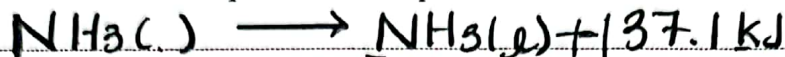
## THINKING

(8 marks)

8. The enthalpy of condensation of ammonia is  $-137.1 \text{ kJ/mol NH}_3$ .

a) Write the thermochemical equation for this process.

[1 mark]



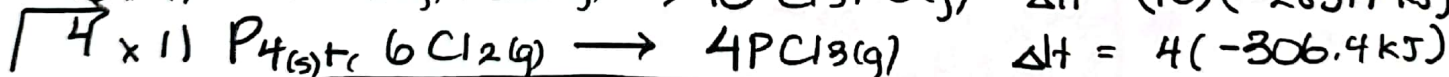
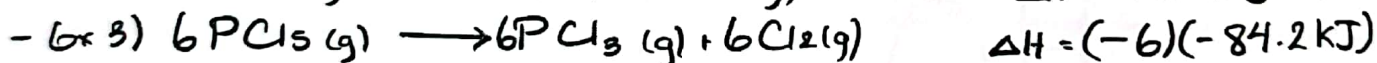
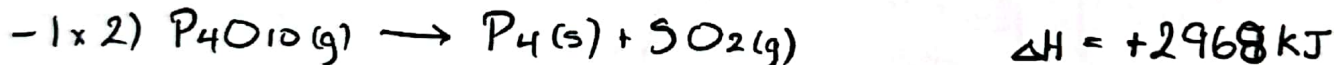
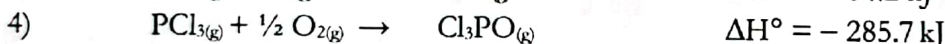
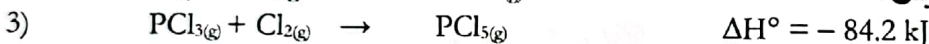
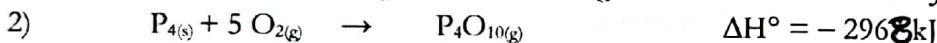
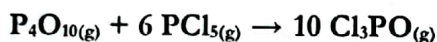
b) State, with a reason, whether the final temperature of the surroundings will be higher or lower than the initial temperature when this process takes place.

[2 marks]

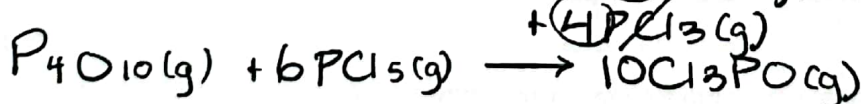
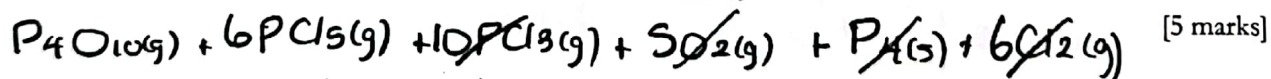
✓ higher

✓ potential energy released (as intermolecular forces form) transferred to surroundings as kinetic energy

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



may wish  
to add to  
see what  
to do



$$\Delta H = 4 \Delta H_1 + (-1) \Delta H_2 + (-6) \Delta H_3 + 10 \Delta H_4$$

$$= -609.4$$

sf from 2968 ↑

$$\Delta H = -609 \text{ kJ}$$

## COMMUNICATION

(10 marks)

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

10. a) Define standard molar enthalpy of formation.

the energy change associated with formation of 1 mole of a substance directly from its elements in their standard states

[2 marks]

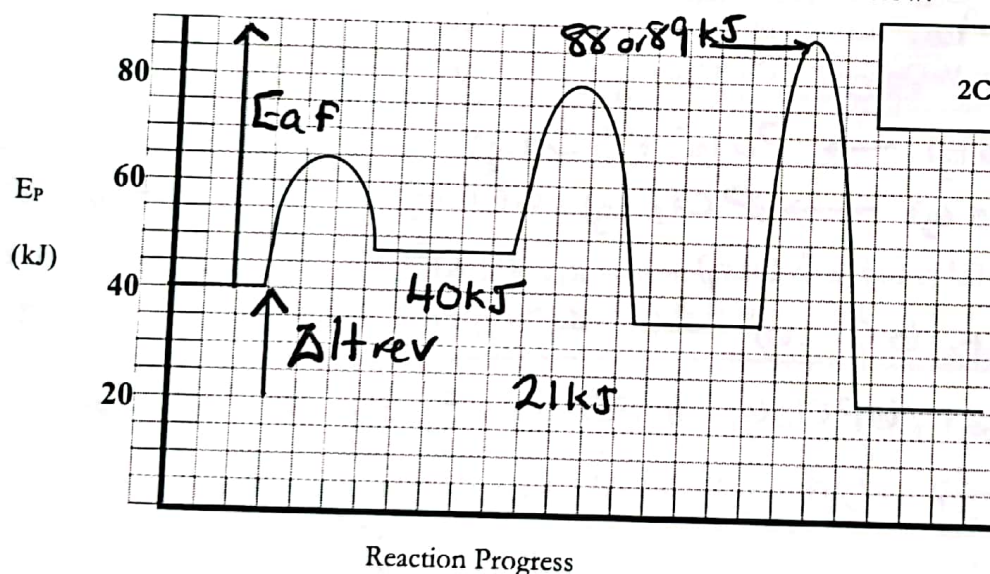
b) The enthalpy change for a chemical reaction can be calculated in various ways. One way is to bond enthalpies and another is to use standard enthalpies of formation. State whether the bond enthalpy method will give a more or less accurate value than standard enthalpies of formation for  $\Delta H$  for the reaction and give one reason for your choice.

less accurate

- average values of same bond in many compounds  
- compound in gaseous state (state change enthalpy not considered)

[2 marks]

11. An energy level diagram (reaction profile) for a chemical reaction is shown below:



a) If you were proposing a reaction mechanism for this reaction, how many steps would you need to include in your mechanism? \_\_\_\_\_ [1 mark]

3 steps

b) If you were given no other information, suggest, with a reason which step suggest is the rate-limiting step [1 mark]

Step 3

highest activation energy

c) Use your graph to determine the following values:

- i) The overall activation energy for the forward reaction 48 kJ (49 kJ)
- ii) The overall enthalpy change for the reverse reaction +19 kJ [2 marks]



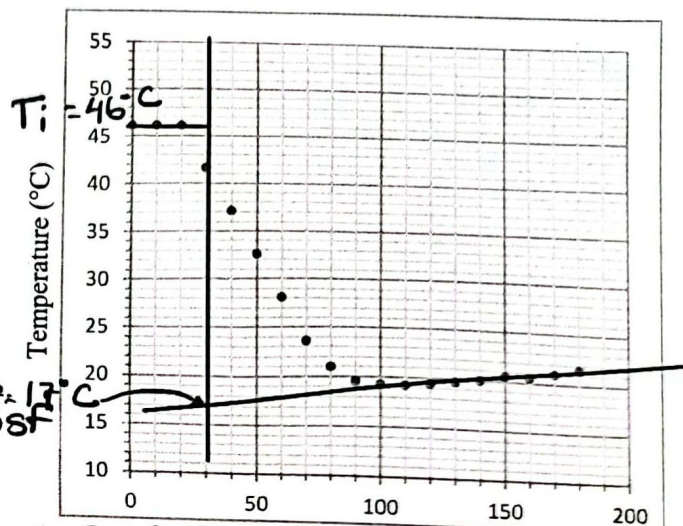
## APPLICATION

(10 marks)

12. A calorimetry experiment was carried out to determine the **molar enthalpy of solution** of lithium chloride. 8.480g of ~~potassium hydroxide (KOH)~~ <sup>lithium chloride (LiCl)</sup> was added to a calorimeter containing 75.00 mL of water. The results of the experiment are shown below:

Calculate the molar enthalpy of solution of lithium chloride.

water  
 $q = mc\Delta t$   $m = 75.00g$   
 $q = (75.0)(4.18)(\Delta t)$   $C_{sp} = 4.18 J/g \cdot ^\circ C$   
 $q = -9091.5J$   $\Delta T = T_f - T_i$   
 $\quad \quad \quad = 17 - 46$   
 $\quad \quad \quad = -29.0^\circ C$   
 $q = -\Delta H$   
 $\Delta H = +9091.5J$



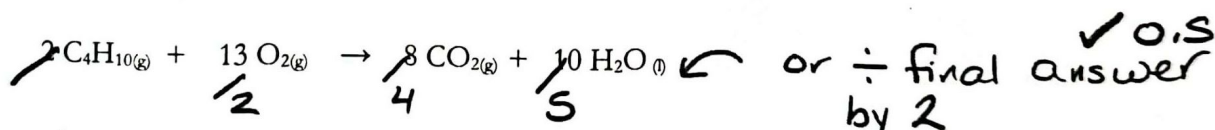
$n = 11.22g \text{ KOH} \times \frac{1 \text{ mol}}{42.39g}$   
 $n = 0.200 \text{ mol}$  [4 marks]

$\Delta H = \frac{+9091.5}{0.200 \text{ mol}}$

Time (s)

$\Delta H = +45.5 \text{ kJ/mol KOH}$  (3sf)

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



break  $\checkmark$  kJ  $\checkmark$  form kJ [4 marks]

3 C-C	3(347 kJ)	8 C=O	8(746)
10 C-H	10(413 kJ)	10 O-H	10(464)
$\frac{13}{2} O=O$	$\frac{13}{2}(498)$		
8408 kJ $\checkmark 0.5$		10608 kJ $\checkmark 0.5$	
$\Delta H = -2200.0$ dec places sf			
$\Delta H = -2.200 \times 10^3 \text{ kJ/mol } C_4H_{10}$			

14. Water freezes at  $0^{\circ}\text{C}$ . On a specific winter day the temperature is  $0^{\circ}\text{C}$  and a puddle is a mixture of ice and water. At night the air temperature drops to  $-10^{\circ}\text{C}$  but the temperature of the puddle does not immediately start to change. Explain why, and state when the temperature will start to change, in terms of energy and energy transfer. [2 marks]

The water will freeze and potential energy released from state change / intermolecular forces forming will transfer as kinetic energy to the water. The temperature of the puddle will only start to decrease when all the water is frozen.

Space for rough work, continuations or corrections