Honour Chemistry: Unit 4 Practice Test: Thermochemistry and Nuclear Chemistry

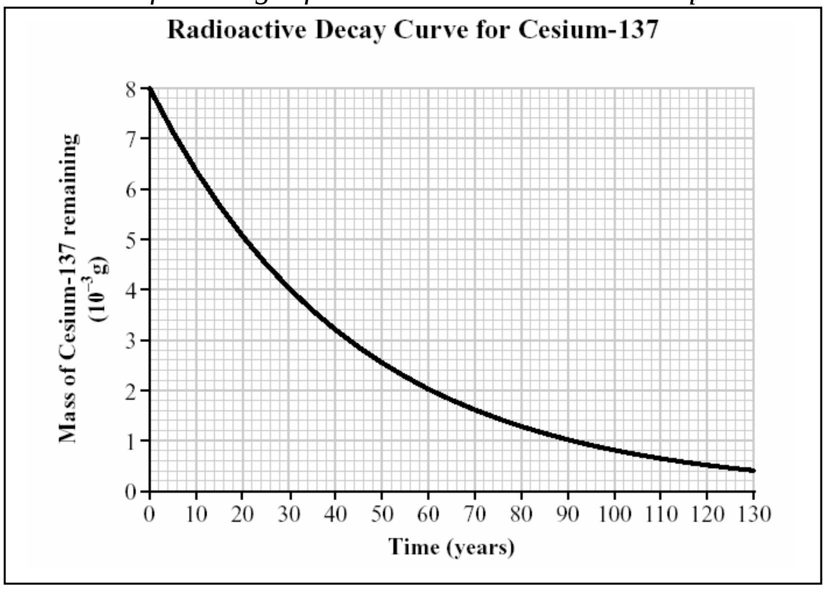
Part A: Multiple Choice and Numerical Response **(1 mark each for Multiple Choice)**
(2 marks each for Numerical Response)

$\Delta E_{\text{bind}} = -\Delta mc^2$	c = speed of light (3.00×10^8 m/s)	1 eV = 1.69×10^{-19} J
(1 kg = 6.022×10^{26} amu , or 1 g = 6.022×10^{23} amu = 1 mole amu)		1 MeV = 1.69×10^{-16} J
(1 Neutron = 1.008665 amu)	(1 Proton = 1.007825 amu)	
$\ln\left(\frac{N}{N_0}\right) = -kt$	$t½ = \frac{\ln 2}{k} = \frac{0.693}{k}$	$N = N_o\left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$

1. The change in energy of five cups of water (1.25 L) heated from 20.0°C to 85.0°C is

A. 340 kJ **B.** 445 kJ **C.** 129 kJ **D.** 563 kJ

Use the following information to answer the next question.



2. Based on the graph above, the half-life of Cesium-137 is

A. 130 years **B.** 65 years **C.** 30 years **D.** 2 years

3. If 72.1 kJ of energy are released, how many moles of oxygen gas would be consumed by the combustion of hydrogen gas to produce gaseous water?

A. 0.500 mol **B.** 0.126 mol **C.** 0.298 mol **D.** 0.149 mol

4. The decomposition equation of sodium hydroxide is $NaOH_{(s)} \rightarrow Na_{(s)} + ½\, O_{2\,(g)} + ½\, H_{2\,(g)} + 425.6$ kJ. Determine the ΔH if 0.250 mol of oxygen gas was produced.

A. +213 kJ **B.** –213 kJ **C.** +426 kJ **D.** –426 kJ

Numerical Response

1. 100 mL of water at 75.0°C was cooled to 0.00°C by adding ice. All the ice melted. To the nearest tenth, the mass of ice added was __________ g.

5. 32.0 g of methane, CH_4, is burned in a calorimeter and the heat released is enough to raise the temperature of 5.00 kg of water from 20.0°C to 27.7°C. From this data, the molar heat of combustion of methane is

A. −2.52 kJ/mol **B.** −80.9 kJ/mol **C.** −161 kJ/mol **D.** −870 kJ/mol

6. Which change produces the most energy?

A. Combustion of 1 mole of methane
B. Conversion of 10 moles of steam at 100°C to ice at −40°C
C. Neutralization of 1 mole of acid
D. Nuclear fission of 0.1 mole of uranium

7. The majority of energy obtained from the burning of a hydrocarbon, gasoline for example, is due to

A. chemical bonds being broken.
B. intermolecular attractions.
C. molecule-to-molecule interactions.
D. transformation of mass to energy in the nucleus.

8. Of the following compounds, which one requires the most energy to decompose it into its elemental parts?

A. $H_2S_{(g)}$ **B.** $H_2O_{2\,(l)}$ **C.** $HClO_{4\,(l)}$ **D.** $HI_{(g)}$

9. If the desired reaction can be written as the algebraic sum of a number of reactions, then the heat of the desired reaction can be written as

A. algebraic difference of the heats of reaction.
B. heat of the reaction of the most reactions.
C. algebraic sum of the heats of reaction.
D. heat of reaction containing compounds.

10. The majority of the energy that we use in society today is from

A. the combustion of fossil fuels.
B. hydroelectricty energy.
C. nuclear energy.
D. electrical energy from solar cells.

Numerical Response

2. Benzene is a gasoline additive. The heat of formation for 1.00 mol of benzene is ______________ kJ.

Use the following information to answer the next question.

Prior to an experiment, the following information was obtained from a chemistry reference source:

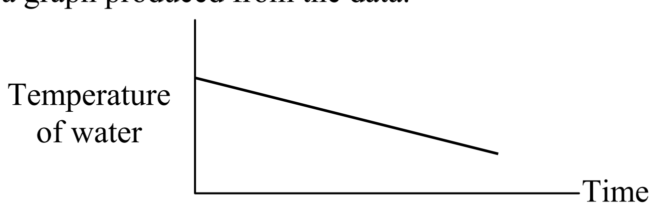
$$\tfrac{1}{2}\,H_{2\,(g)} + \tfrac{1}{2}\,I_{2\,(s)} \rightarrow HI_{(g)} \qquad \Delta H = +25.9\text{ kJ}$$
$$I_{2\,(s)} \rightarrow I_{2\,(g)} \qquad \Delta H = +61.8\text{ kJ}$$

11. The predicted ΔH value for the reaction represented by the equation $H_{2\,(g)} + I_{2\,(g)} \rightarrow 2\,HI_{(g)}$ should be

A. +113.6 kJ **B.** +87.7 kJ **C.** −10.0 kJ **D.** −35.9 kJ

Use the following information to answer the next question.

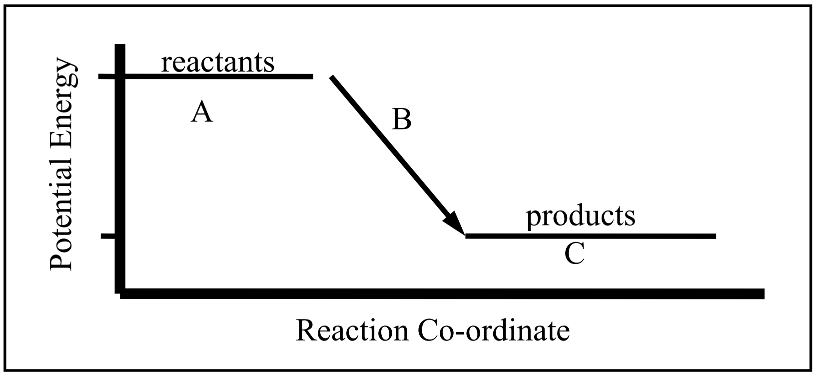
A student performs an experiment using a calorimeter that contains water. The following is a graph produced from the data.



12. The best interpretation from the data is that the reaction is

A. endothermic and that the kinetic energy of the water is decreasing
B. endothermic and that the kinetic energy of the water is increasing
C. exothermic and that the kinetic energy of the water is decreasing
D. exothermic and that the kinetic energy of the water is increasing

Use the following diagram to answer the next question.



13. The diagram could apply to a nuclear reaction or a chemical reaction. However, in the

A. nuclear reaction, section B will be much larger than in the chemical reaction
B. nuclear reaction, section B will be much smaller than in the chemical reaction
C. nuclear reaction, section C must be above section A
D. chemical reaction, section C must be above section A

Use the following information to answer the next question.

$7\ C_{(s)} + 7\ H_{2\,(g)} \rightarrow C_7H_{14\,(l)}$	$\Delta H = -62.1$ kJ
$C_{(s)} + O_{2\,(g)} \rightarrow CO_{2\,(g)}$	$\Delta H = -393.5$ kJ
$H_{2\,(g)} + \frac{1}{2}\ O_{2\,(g)} \rightarrow H_2O_{(g)}$	$\Delta H = -241.8$ kJ

Numerical Response

3. To the nearest tenth, the amount of heat released when 1.80 g of $C_7H_{14\,(l)}$ are burned is __________ kJ.

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14. Which of the following statements is **true** for an endothermic reaction?

A. Change in potential energy for the reaction is negative.
B. Energy is a product in the chemical equation.
C. The temperature of the surroundings increases.
D. The potential energy of the products is greater than the potential energy of the reactants.

15. In the reaction $C_{25}H_{52\,(s)} + 38\ O_{2\,(g)} \rightarrow 25\ CO_{2\,(g)} + 26\ H_2O_{(g)}$, the energy released by the reaction of the paraffin fuel is called the molar enthalpy of

A. formation **B.** vaporization **C.** combustion **D.** decomposition

Use the following information to answer the next question.

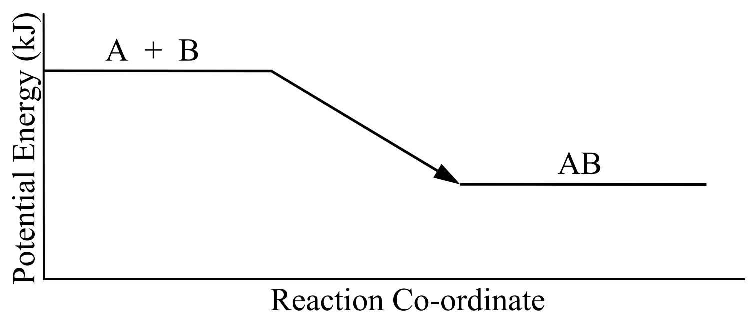
Phosphorus, $P_{4\,(s)}$, reacts spontaneously with chlorine gas to form solid phosphorus pentachloride. In carrying out this reaction, the following data were collected:

Mass of calorimeter water	0.800 kg
Initial temperature of water	21.3°C
Final temperature of water	32.8°C
Mass of phosphorus	3.10 g
Mass of chlorine	excess

Numerical Response

4. To the nearest kJ/mol, the experimental value for the heat of formation of $PCl_{5\,(s)}$ is – ________ kJ/mol.

Use the following diagram to answer the next question.



16. If AB represents the product of a chemical reaction, the reaction is one in which

A. potential energy increases **B.** energy is released **C.** heat is absorbed **D.** ΔH is positive

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Use the following information to answer the next question.

A particular nuclear fission reaction of uranium-235 is represented by

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{55}Cs + ^{ab}_{cd}\boldsymbol{X} + 3\,^{1}_{0}n$$

where element ***X*** is unknown.

Numerical Response

5. The fission product in this reaction is represented by $^{ab}_{cd}\boldsymbol{X}$.
The values of ***a***, ***b***, ***c***, and ***d*** are ____, ____, ____, and ____.

Use the following information to answer the next question.

A student was given the following equation.

$$2\,Na_{(s)} + 2\,H_2O_{(l)} \longrightarrow 2\,NaOH_{(s)} + H_{2\,(g)}$$

Numerical Response

6. To the nearest kJ, the heat of reaction of the above balanced equation is – ___________ kJ.

Use the following information to answer the next question.

Molar Heats of Formation for Silicon Halides

$SiF_{4\,(g)}$	−1617 kJ/mol	$SiBr_{4\,(l)}$	−458 kJ/mol
$SiCl_{4\,(l)}$	−688 kJ/mol	$SiI_{4\,(s)}$	−190 kJ/mol

17. Which silicon halide is the most stable?

A. $SiF_{4\,(g)}$ **B.** $SiCl_{4\,(l)}$ **C.** $SiBr_{4\,(l)}$ **D.** $SiI_{4\,(s)}$

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18. The Euglena is an organism that can produce glucose by photosynthesis when light is present. The major energy conversion in the Euglena, in the presence of light, is best described as

A. exothermic, with a decrease in kinetic energy
B. exothermic, with a decrease in potential energy
C. endothermic, with an increase in kinetic energy
D. endothermic, with an increase in potential energy

19. Nuclear radiation exists in several different forms. Listed from greatest to least in their ability to penetrate human tissue, the order of three of these forms is

A. alpha, beta, gamma **B.** gamma, beta, alpha **C.** gamma, alpha, beta **D.** alpha, gamma, beta

Numerical Response

7. An outdoor mercury thermometer contains 1.02 g of mercury. On a winter day, the thermometer records a change in temperature from −38.0°C to −13.0°C. To the nearest hundredth, the amount of energy the mercury absorbs is ___________ J.

Use the following information to answer the next two questions.

Limestone is used as a raw material in the production of lime, which has a wide range of industrial applications. Lime, $CaO_{(s)}$, in the plant is produced by roasting crushed limestone, $CaCO_{3\,(s)}$, in kilns. The process of removing carbon dioxide from the limestone is referred to as calcination. The lime can be used to produce slaked lime, $Ca(OH)_{2\,(s)}$, through the careful addition of liquid water.

The demand for lime and slaked lime had increased in the last few years because it can be used in the treatment of industrial wastes and raw sewage, and in the purification of water.

20. The molar heat of reaction for the production of lime from limestone is

A. −634.9 kJ/mol **B.** +1207.6 kJ/mol **C.** +179.2 kJ/mol **D.** −179.2 kJ/mol

21. The production of slaked lime from lime can be classified as an

A. exothermic phase change
B. endothermic chemical change
C. endothermic phase change
D. exothermic chemical change

Part B: Written Response

1. A student performed an experiment during which 17.04 g of hydrogen sulfide gas were burned in a calorimeter to form $H_2O_{(g)}$ and $SO_{2\,(g)}$. The heat produced was used to heat 1.50 L of water from 14.60°C to 55.20°C. **(10 marks)**

- **a.** Write the balance equation. Using the Standard Molar Enthalpies of Formation provided in the data booklet, calculate the molar heat of combustion of $H_2S_{(g)}$.
- **b.** Clearly draw and label the potential energy diagram that represents the combustion of one mole of gaseous hydrogen sulfide.
- **c.** Use the student's data to determine the experimental value for the molar heat of combustion of $H_2S_{(g)}$.
- **d.** List one factor and how it may account for any difference between ΔH values in part **a** and part **c**.

2. Tritium, ^3H, is a radioisotope of hydrogen having a half-life of 12.3 years. **(4 marks)**

- **a.** Calculate the decay rate of the tritium. Include proper unit.
- **b.** How long does it take to for a sample of tritium to decay to 5% of the original amount?

3. Uranium-235 has an atomic mass of 235.0439 amu. **(5 marks)**

- **a.** Determine the mass defect (in amu) of U-235.
- **b.** Calculate the binding energy of U-235 in J/nucleus and kJ/mol.

Part A: Multiple Choice and Numerical Response

1. A	**2.** C	**3.** D	**4.** B	**5.** B	**6.** D	**7.** A	**8.** B	**9.** C	**10.** A
11. C	**12.** A	**13.** A	**14.** D	**15.** C	**16.** B	**17.** A	**18.** D	**19.** B	**20.** C
21. D									

Numerical Response (2 marks each for answers below)

1. 94.2	**2.** 49.1	**3.** 80.4	**4.** 385
5. 9237	**6.** 280	**7.** 3.57	

Part B: Written Response

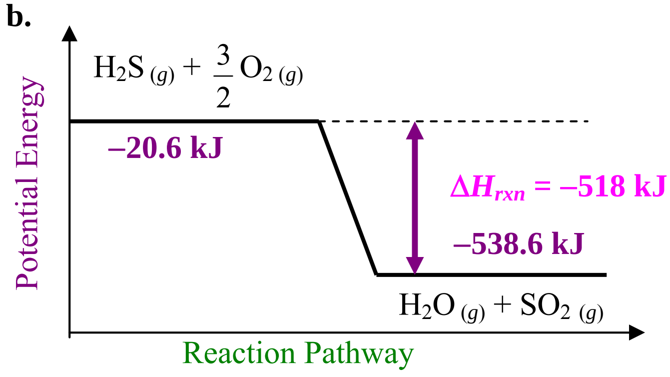
1. **a.** $\Delta H_{rxn} = -518$ kJ/mol of H_2S burned

c. Experimental $\Delta H_{rxn} = -510$ kJ/mol of H_2S burned

d. Some Possible Errors:

- Heat Lost due to imperfect calorimeter (lack of insulation).
- Did not account for heat gained from the calorimeter container.
- Did not account for gas expansion of the products and consequently work done by the system to lower the heat generated.

b.



2. **a.** 0.0563 yr^{-1} **b.** 53.2 yrs

3. **a.** −1.915095 amu **b.** 2.86×10^{-10} J/nuclueus = 1.72×10^{11} kJ/mol