Unit 5 Summative Assessment Practice

Show your work for each question in the space provided. Examples and equations may be included in your responses where appropriate. For calculations, clearly show the method used and the steps involved in arriving at your answers. You must show your work to receive credit for your answer. Pay attention to significant figures.

$$2\ Li(s) + 2\ H_2O(l) \rightarrow 2\ LiOH(aq) + H_2(g)$$

1. The reaction between Li(*s*) and $H_2O(l)$ is represented by the equation shown above.

(a) A student makes the claim that the reaction represented by the equation shown above is classified as an oxidation-reduction (redox) reaction.

(i) Do you agree or disagree with the student's claim? ______________________________

(ii) Justify your answer to (a)(i) by assigning oxidation numbers to each element on both sides of the chemical equation.

Oxidation Numbers (Reactants)			Oxidation Numbers (Products)			
Li =	H =	O =	Li =	H (in LiOH) =	O =	H (in H_2) =

(b) Write the balanced net ionic equation for the reaction represented by the equation shown above. You do not need to include the symbols for phases of matter such as (*s*) or (*aq*) in your equation.

Trial	Mass of Li(*s*)	Form of Li(*s*)	Volume of $H_2O(l)$	Temperature of $H_2O(l)$
1	5.0 g	single piece of metal	500 mL	20°C
2	5.0 g	single piece of metal	500 mL	40°C

(c) Two different trials for this reaction were performed under different conditions according to the information shown above. In which trial should the reaction occur at the faster initial rate? Justify your choice by describing the how the collisions between reactant particles are affected by the specific change that was made in the experimental conditions.

$$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$$

2. Gaseous ammonia, $NH_3(g)$, can be synthesized from $N_2(g)$ and $H_2(g)$ according to the equation shown above. At a certain point in time during the reaction, the rate of formation of $NH_3(g)$ was equal to 0.018 mol L^{-1} s^{-1}. Calculate the rate of disappearance of $H_2(g)$ at that same point in time. Include units in your answer.

$$2\ HgCl_2(aq) + C_2O_4^{2-}(aq) \rightarrow 2\ Cl^-(aq) + 2\ CO_2(g) + Hg_2Cl_2(aq)$$

3. The equation for the reaction between $HgCl_2(aq)$ and $C_2O_4^{2-}(aq)$ is shown above. The initial rate of formation of $Cl^-(aq)$ at constant temperature was measured in different trials with various initial concentrations of the reactants, as shown in the following table.

Experiment	Initial $[HgCl_2]$ (M)	Initial $[C_2O_4^{2-}]$ (M)	Initial Rate of Formation of $Cl^-(aq)$ (M min^{-1})
Trial 1	0.0850	0.200	5.44×10^{-5}
Trial 2	0.0850	0.400	2.18×10^{-4}
Trial 3	0.0425	0.400	1.09×10^{-4}
Trial 4	0.0675	?	3.01×10^{-4}

(a) Determine the order of the reaction with respect to $HgCl_2$. Justify your answer.

(b) Determine the order of the reaction with respect to $C_2O_4^{2-}$. Justify your answer.

(c) Write the rate law for the reaction. ______________________________

(d) Calculate the value of the rate constant k for this reaction. Include units in your answer.

(e) Calculate the initial concentration of $C_2O_4^{2-}$ in Trial 4. Include units in your answer.

4. A kinetics experiment was done to study the decomposition of nitrogen dioxide (NO_2). The concentration of $NO_2(g)$ in a rigid reaction vessel is monitored over time as it decomposes at 500 K. The data from the experiment is shown in the table below.

(a) Fill in the missing data in the table below. Round off all of the calculated values in the table to three significant figures.

Time (*s*)	$[NO_2]$ (*M*)	$\ln[NO_2]$	$1/[NO_2]$ (M^{-1})
0.0	0.100		
20.0	0.0676		
40.0	0.0510		
60.0	0.0410		
80.0	0.0342		

(b) What is the order of the reaction with respect to $NO_2(g)$? Justify your answer.

(c) Based on your answer to part (b),
write the rate law for this reaction. ____

(d) The initial reaction rate is determined to be 0.0012 mol L^{-1} s^{-1}. Calculate the value of the rate constant k for the decomposition of $NO_2(g)$ at 500 K. Include units in your answer.

(e) Calculate the time required, in seconds, for the concentration of NO_2 to change from 0.100 *M* to 0.0500 *M* in this experiment.

(f) Calculate the concentration of NO_2, in moles per liter, that should be present in the reaction vessel in this experiment when the reaction time is equal to 100.0 seconds.

4. (continued)

The following two-step mechanism has been proposed for the decomposition of NO_2.

Step 1 (slow step) $NO_2(g) \rightarrow NO(g) + O(g)$

Step 2 (fast step) $NO_2(g) + O(g) \rightarrow NO(g) + O_2(g)$

(g) Based on this proposed mechanism, write the balanced equation for the decomposition of NO_2.

(h) Is the rate law that is derived from this proposed mechanism consistent with the experimentally determined rate law that you wrote in part (c)? Justify your answer.

5. Carbon–11 (^{11}C) is an isotope of carbon that undergoes a nuclear decay process in which it is converted into boron–11 (^{11}B). The half-life for this decay process is equal to 20.3 minutes.

(a) Calculate the value of the rate constant (k) for the nuclear decay of ^{11}C.
Include units in your answer.

(b) A pure sample of ^{11}C with a mass of 275 mg undergoes nuclear decay. Calculate the mass, in milligrams, of ^{11}C present in this sample after 75.0 minutes.

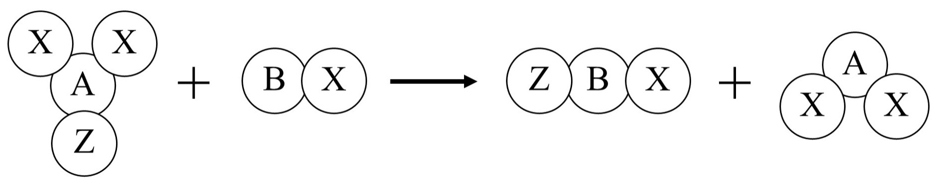
(c) A pure sample of ^{11}C with a mass of 182 mg undergoes nuclear decay. Calculate the time, in minutes, for the mass of ^{11}C to decrease to a value of 36 mg.

6. The following three-step mechanism has been proposed for the reaction between Cl_2 and C_5H_{10}.

Step 1 (slow step)	$Cl_2 \rightarrow 2\ Cl$
Step 2 (fast step)	$Cl + C_5H_{10} \rightarrow HCl + C_5H_9$
Step 3 (fast step)	$Cl + C_5H_9 \rightarrow C_5H_9Cl$

(a) Based on this proposed mechanism, write the balanced equation for the reaction between Cl_2 and C_5H_{10}. ______________________________

(b) Write the rate law that is derived from this proposed mechanism. ______________________________

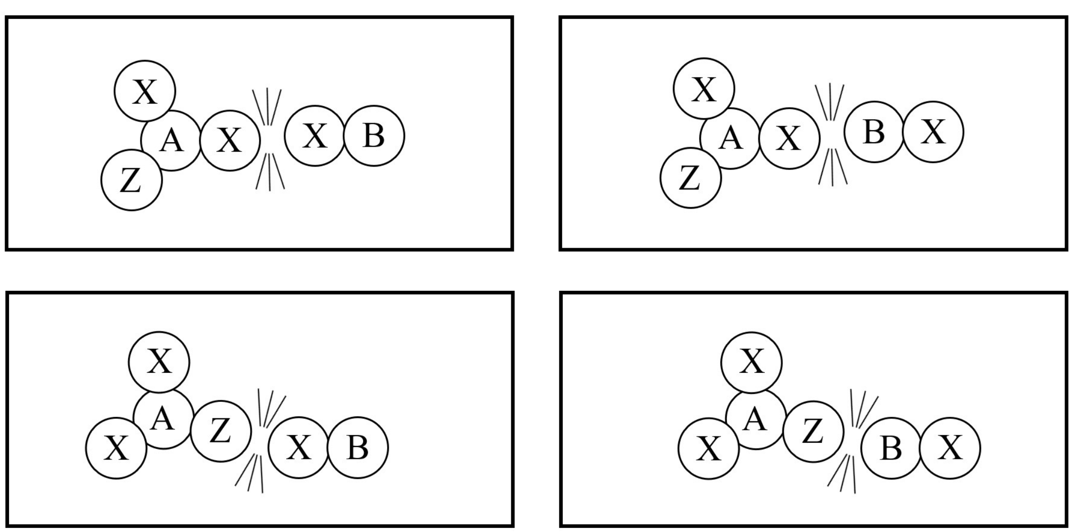


7. The elementary reaction that occurs between $AX_2Z(g)$ and $BX(g)$ is represented by the particle diagram shown above.

(a) During this reaction, a bond is broken between __________ and __________.

(b) During this reaction, a bond is formed between __________ and __________.

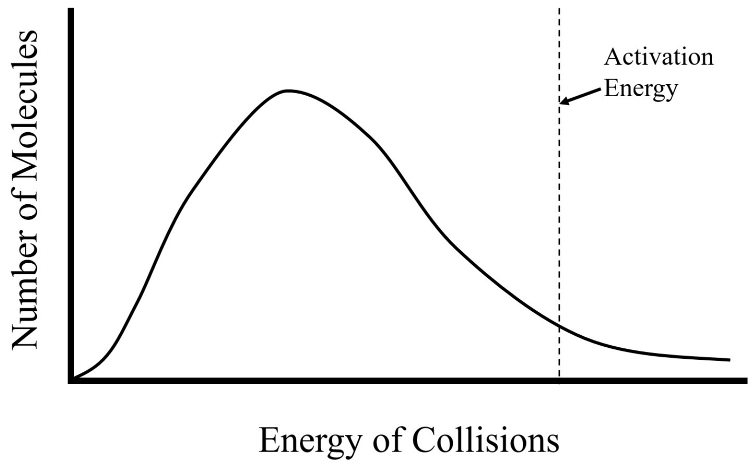
(c) The diagrams below represent collisions between reactant particles. Select the diagram that is most likely to result in the formation of the products in this elementary reaction. Assume that each collision occurs with sufficient energy to overcome the activation energy associated with the reaction.



$$X_2(g) \rightarrow 2\,X(g)$$

8. The conversion of $X_2(g)$ into $X(g)$ is represented by the equation above. It is observed that this reaction proceeds at a very slow rate at a temperature of 20°C. The reaction rate increases at a temperature of 50°C.

   The graph below shows a distribution for the collision energies of reactant molecules at 20°C. Draw a second curve on the graph that shows the distribution for the collision energies of reactant molecules at 50°C.



9. The diagram above represents data from an experiment involving the chemical reaction represented by the following equation.

$$2\,X_2Y_2 \rightarrow 2\,X_2Y + Y_2$$

   The concentration of X_2Y_2 was monitored over time during the reaction. The graph shown above illustrates the relationship between the natural log (ln) of the concentration of X_2Y_2 and the reaction time (in minutes).

   (a) Write a rate law for this reaction that is consistent with the information presented in the graph. ____

9. (continued)

(b) What are the units of the rate constant (k) in the rate law that you wrote in part (a)? ____________________

(c) The initial reaction conditions for Trial 1 and Trial 2 are different. Identify the variable that was changed in Trial 2 that best explains the difference in the appearance of the data in the graph for Trials 1 and 2. ____________________

(d) A third trial was performed for this same reaction, in which the initial concentration of X_2Y_2 was the same value as what was used in Trial 2. The initial temperature of the reaction in Trial 3 was lower the initial temperature in Trial 2. Based on this information, draw a line on the graph on the previous page that shows how the data for ln[X_2Y_2] versus time in Trial 3 would appear differently than the data in Trial 2. The line that you draw for Trial 3 should represent data collected over the same time interval as what was used in Trials 1 and 2.

10. Answer the following questions related to ethylene, C_2H_4.

H	C	C	H
	H	H	

(a) In the box shown above, draw the correct Lewis electron-dot diagram for the C_2H_4 molecule in which each carbon atom obeys the octet rule. Show all bonding and nonbonding valence electrons.

$C_2H_4(g)$ reacts with $HCl(g)$ to produce $C_2H_5Cl(g)$, as represented by the following equation.

$$C_2H_4(g) + HCl(g) \rightarrow C_2H_5Cl(g)$$

(b) This reaction is carried out in a rigid reaction vessel. Do you predict that the total pressure in the reaction vessel should decrease, increase, or remain the same as the reaction proceeds under conditions of constant temperature? Justify your answer in terms of a description of the gas particles.

10. (continued)

It is proposed that the formation of $C_2H_5Cl(g)$ from $C_2H_4(g)$ and $HCl(g)$ proceeds via the following two-step reaction mechanism.

Step 1 (slow step) $\quad C_2H_4(g) + HCl(g) \rightarrow C_2H_5^+(g) + Cl^-(g)$

Step 2 (fast step) $\quad C_2H_5^+(g) + Cl^-(g) \rightarrow C_2H_5Cl(g)$

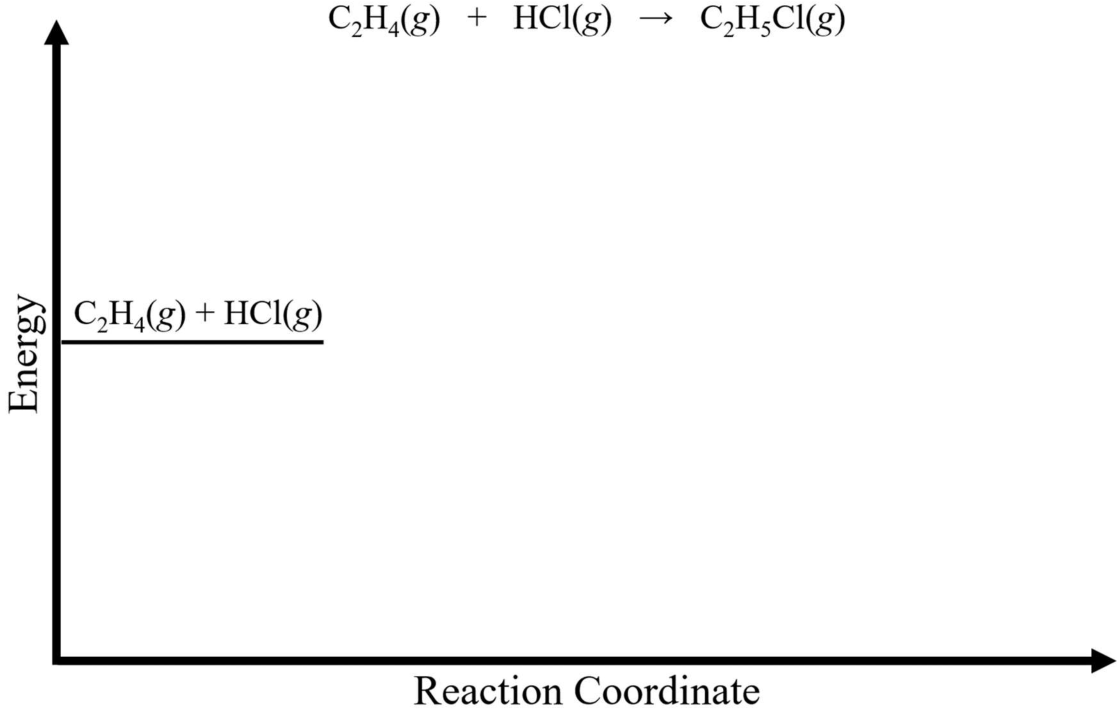
(c) Write the rate law that is derived from this proposed mechanism. ______________________________

(d) A student makes the claim that $C_2H_5^+(g)$ behaves as an intermediate in the proposed mechanism shown above. Do you agree or disagree with the student's claim? Justify your answer.

(e) It is determined that this overall chemical reaction is classified as exothermic. On the incomplete energy diagram below, draw a curve that shows the following two details.

- the change in energy for the overall chemical reaction
- the relative activation energy values for the two elementary steps of the proposed reaction mechanism.

$$C_2H_4(g) + HCl(g) \rightarrow C_2H_5Cl(g)$$



(f) On the energy diagram that you drew above, draw a vertical arrow (↕) to clearly indicate the magnitude of the activation energy barrier for the rate-determining step of the proposed two-step reaction mechanism.