Chemist: _____

Wednesday November 2, 2022 Period 5

Rates of Reactions

SCH4U1 UNIT 2 Test 1 (A of L)

Knowledge:	/10
Thinking:	/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.

1.	A	B	(C)	D	E	*3.*	A	B	C	D	(E)
2.	A	B	C	(D)	E	*4.*	(A)	B	C	D	E

1. For the reaction below, the rate of production of C is 1.2 mol/L•s.

$$3A + B \rightarrow 2C + D_2$$

Which of the following below describes the **rate of consumption of reactant A**?

A. $\frac{\Delta[A]}{\Delta t} = -1.8$ mol/L•s

B. $\frac{\Delta[A]}{\Delta t} = -0.80$ mol/L•s

(C.) $-\frac{\Delta[A]}{\Delta t} = 1.8$ mol/L•s

$1.2 \times \frac{3A}{2C} = 1.8$

D. $-\frac{\Delta[A]}{\Delta t} = 1.2$ mol/L•s

E. $-\frac{\Delta[A]}{\Delta t} = 0.80$ mol/L•s

2. Which statement(s) is/are false for the rate of a chemical reaction?

A. Decreasing the concentration of an aqueous reactant will decrease the reaction rate.
B. Decreasing the temperature will decrease the reaction rate.
C. Adding a catalyst will increase the reaction rate.
(D.) Decreasing the particle size of a solid reactant will decrease the reaction rate.
E. ~~In~~creasing the pressure of a gaseous reactant will increase the reaction rate

3. Which statement(s) is/are **true** about using sulfuric acid as a catalyst in the following reaction?

$$CH_3–CO–CH_3(aq) + I_2(aq) \xrightarrow{H^+(aq)} CH_3–CO–CH_2–I(aq) + HI(aq)$$

I. ✓ The catalyst increases the rate of reaction.
II. ✓ The catalyst lowers the activation energy for the reaction.
III. ~~X~~ The catalyst has not been consumed at the end of the chemical reaction.

A. I only
(C.) I and II only
E. I, II and III
B. II only
D. II and III only

4. The reaction $NO_{2(g)} + NO_{(g)} \rightarrow N_2O_{3(g)}$ has the rate expression

$$\text{rate} = k[NO]^2[NO_2]$$

The concentration of NO is increased by a factor of 2 and the concentration of NO_2 is decreased by a factor of 3. What factor will the new rate increase by?

(A.) Increase by a factor of 1.3
B. Decrease by a factor of 1.3
C. Increase by a factor of 12
D. Decrease by a factor of 5
E. The rate will not change

$\left(\frac{2}{3}\right)^2 = \frac{4}{3}$

SCH4U1
UNIT 2 – Quiz 1 (RATES)

Chemist: _____

Wednesday November 2, 2022 Period 5

Communication **(8 marks)**

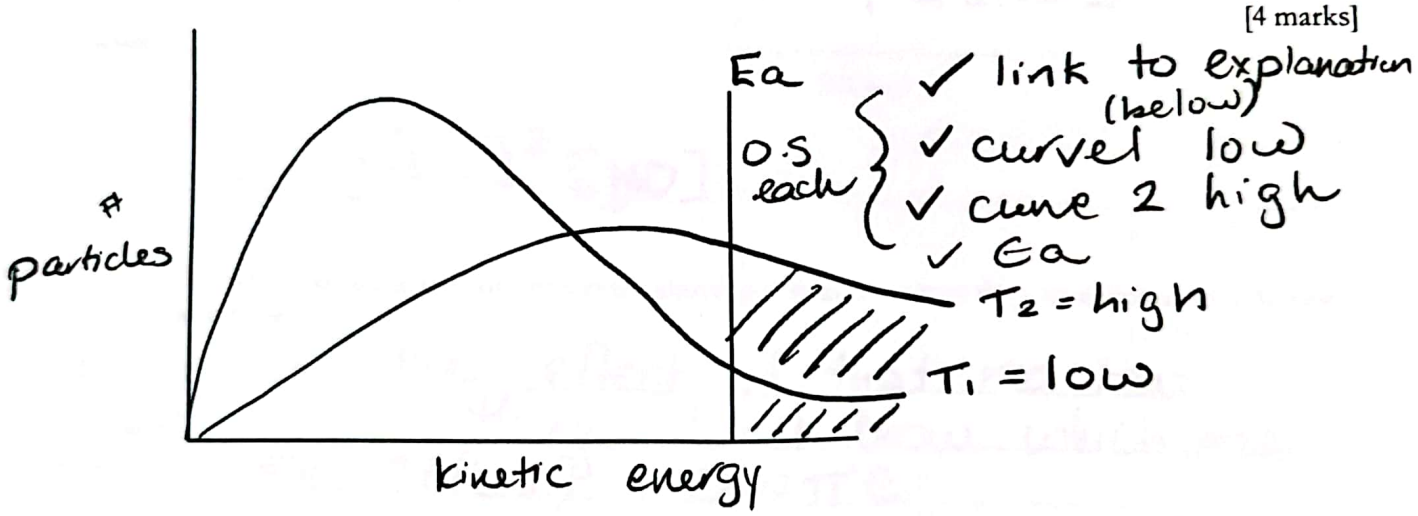
Overall form (showing work, units, significant figures etc.) throughout quiz _____[2 marks]

9. Some factors that affect reaction rate affect the frequency of collisions and some affect the proportion of effective collsions. Explain the **difference between collision frequency and proportion of effective collisions**. [2 marks]

- collision frequency is the overall number of collisions in a given time (regardless of whether they result in a reaction) ✓
- proportion of effective collisions is the fraction of the collisions that occur that result in a chemical reaction ✓ OWTTE

10. Draw a **Maxwell-Boltzmann Distribution** that shows the effect of **increasing the temperature** on reaction rate, and **use/annotate/label** the diagram to **explain the MAIN effect** of temperature on reaction rate.

[4 marks]



0.5 each: ✓ link to explanation (below) ✓ curve 1 low ✓ curve 2 high ✓ Ea

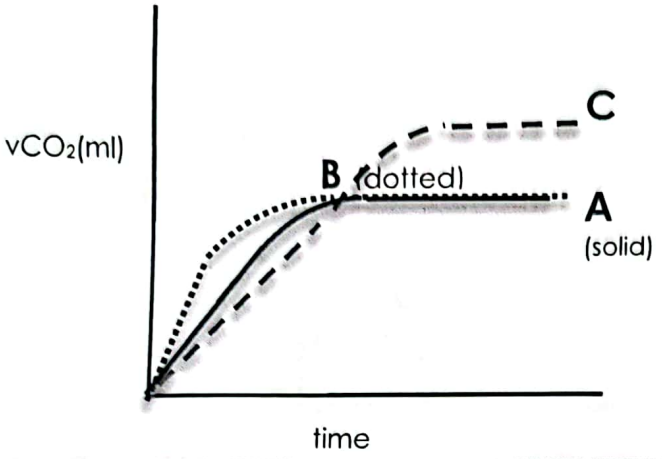
increasing temperature increases the proportion of effective collisions by increasing the number of particles with kinetic energy greater than the activation energy. As seen in graph, only particles to the right of the Ea line have enough energy to react - that number is greater at higher temperature (above) therefore rate increases ✓

SCH4U1 Chemist: _____

UNIT 2 – Quiz 1 (RATES) Wednesday November 2, 2022 Period 5

Thinking **(8 marks)**

7. In experiment A below, **50.0 mL of 0.100 mol/L nitric acid is added to an excess of powdered of calcium carbonate at 30°C.** The rate of reaction is monitored by measuring the volume of carbon dioxide produced.



Suggest a single **change for each of experiments B and C** that would give the experimental results observed. **Explain**/justify your reasoning. [4 marks]

B: higher temperature * not catalyst now brown
- same moles limiting reactant
- faster rate

C: lower concentration of nitric acid but larger volume
- slower rate
- more moles limiting reactant

8. Nitrogen dioxide reacts at 1280 °C with carbon monoxide to form nitrogen monoxide and carbon dioxide. All reactants and products are in the gaseous phase.

The kinetics of the reaction were studied at this temperature. The table shows the initial rate of reaction for different concentrations of each reactant.

experiment	$[NO_2(g)]$/ mol /L	$[CO\ (g)]$/ mol /L	Initial rate/ mol /L•s
1	2.40×10^{-2}	5.20×10^{-2}	4.02×10^{-2}
2	2.40×10^{-2}	1.04×10^{-1}	1.62×10^{-1}
3	1.20×10^{-2}	1.04×10^{-1}	8.05×10^{-2}

a) Determine **the order of the reaction with respect to CO and NO_2.** (work must be shown for full marks)

NO_2 using 2 : 3

$\frac{r_2}{r_1} = \left(\frac{C_2}{C_1}\right)^n$

$\frac{1.62\times10^{-1}}{8.05\times10^{-2}} = \left(\frac{2.40\times10^{-2}}{1.20\times10^{-2}}\right)^n$

$n = 1$

CO using 1 & 2

$\frac{1.62\times10^{-1}}{4.02\times10^{-2}} = \left(\frac{1.04\times10^{-1}}{5.20\times10^{-2}}\right)^m$

$m = 2$

order for NO_2 is 1
for CO is 2

[2 marks] -1 0.5 comm if not stated

b) Use experiment 3 to determine **the value of the rate constant (k) for the reaction. Units are NOT required**

$r = k[NO_2][CO]^2$

$8.05\times10^{-2} = k(1.20\times10^{-2})(1.04\times10^{-1})^2$

$r = 6.20\times10^2$ 3sf

-0.5 if not used

[1 mark] 0.5 comm

c) Write the **rate law equation** for the reaction. $r = 6.20\times10^2[NO_2][CO]^2$ [1 mark]

allow ECF throughout question

Knowledge continued

5. a) In order to occur, the reactants in a chemical reaction must collide. Not all reactions, however, result in a chemical reaction occurring. State the **collision requirements that must be met** in order for the chemical reaction to occur.

✓ - correct collision geometry
✓ enough energy for collision to result in a reaction (energy > activation energy)

[2 marks]

b) Explain the effect of **increasing the concentration** of an aqueous reactant on the rate of a chemical reaction.

more particles in the same volume means higher collision frequency, therefore a higher reaction rate ✓

[2 marks]

6. In the following chemical reaction

$$5Br^-(aq) + BrO_3^-(aq) + 6H^+(aq) \rightarrow 3Br_2(aq) + 3H_2O(l)$$

0.195 mol of $H^+_{(aq)}$ are consumed in 1.50 minutes

Calculate the **average rate of the reaction** in terms of $\mathbf{Br_{2(aq)}/s}$

$\frac{0.195 \text{ mol } H^+}{1.50 \text{ min}}$ ✓ $\times \frac{1 \text{ min}}{60 \text{ s}} \times \frac{3 Br_2}{6 H^+} = 1.08 \times 10^{-3}$ 0.5 each

$+\frac{\Delta Br_2}{\Delta t} = 1.08 \times 10^{-3}$ mol/s

[2 marks]

-0.5 com sf
-0.5 com units

Space for Rough Work, Continuation or Corrections

SCH4U1 Chemist: _____

UNIT 2 – Quiz 1 (RATES) Wednesday November 2, 2022 Period 5

Application **(10 marks)**

11. A student wishes to measure the rate of the following chemical reaction:

$$NH_4Cl_{(s)} + NaOH_{(aq)} \rightarrow NH_{3(g)} + NaCl_{(aq)} + H_2O_{(l)}$$

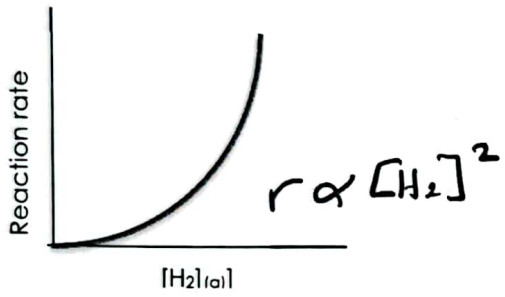
Describe **one method** that could be used to measure the rate and **explain why** it would work: [2 marks]

various - gas produced, mass change, pH change 1 for measurement type 1 for why works (eg mass change due to gas loss)

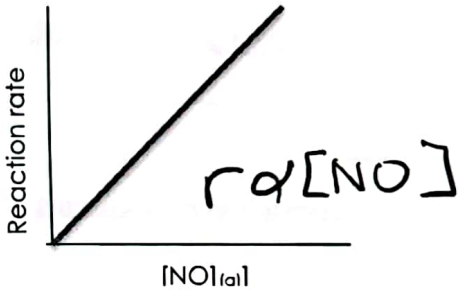
12. Nitrogen monoxide is reacted with hydrogen according to the following reaction:

$$2NO_{(g)} + 2H_{2(g)} \rightarrow N_{2(g)} + 2H_2O_{(g)}$$

A scientist carries out an experiment where they first change the concentration of H_2 only, and then change the concentration of NO only. The graphs below show the results obtained.



$r \propto [H_2]^2$



$r \propto [NO]$

a) State the rate law for the reaction:

$r = k[H_2]^2[NO]$

[2 marks]

b) Explain why, when doing the type of experiment above, it is **best** to change the concentration of only **one reactant at a time**. [1 mark]

to isolate the effect of that reactant (changing two things don't know which one caused the effect) OWTTE

13. 11. A possible reaction mechanism has been proposed for a chemical reaction

i. $F_2 + IBr \rightarrow FI + FBr$ Ea = ?

ii. $FI + IBr \rightarrow I_2 + FBr$ Ea = ?

a) Determine the **overall chemical equation** that relates to this reaction mechanism. [1 mark]

$F_2 + 2IBr \rightarrow I_2 + 2FBr$

b) Identify any **reaction intermediate(s)** for the reaction [1 mark]

FI

Question continues on next page……