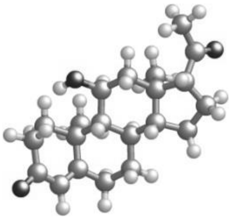

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Class: ………………

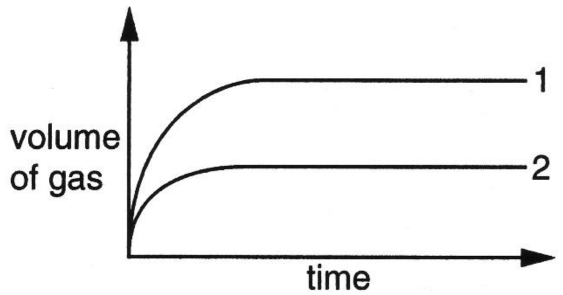
Date: …… / …… / ……

<u>Rate of Reaction Graphs – One</u> – Answers

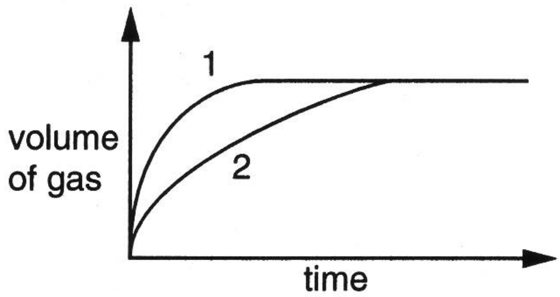
- All of the graphs below show data collected for the reaction between hydrochloric acid and magnesium:

$$2HCl(aq) + Mg(s) \rightarrow MgCl_2(aq) + H_2(g)$$

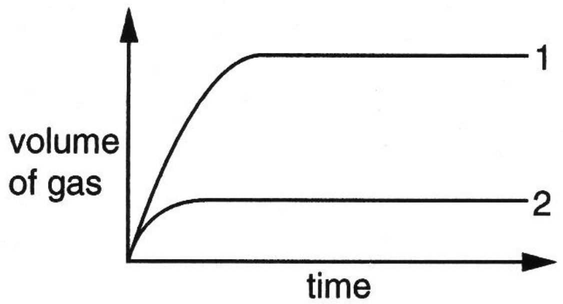
Experiment **A**



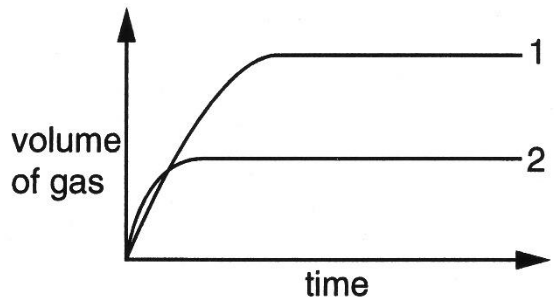
Experiment **B**



Experiment **C**



Experiment **D**



1. Study the graph for experiment **A**. In reaction **1**, 20.0 cm^3 of 1.0 mol/dm^3 hydrochloric acid was reacted with an excess of magnesium ribbon. What change(s) to this experiment would give the results observed in reaction **2**?

The initial rate of reaction **2** is the *same* as the initial rate of reaction **1**. The volume of $H_2(g)$ produced by reaction **2** is exactly *half* the volume produced by reaction **1**. Moles of HC*l*(aq) – the limiting reagent – used for reaction **2** must be exactly *half* the moles of HC*l*(aq) used for reaction **1**. This is achieved by using *half* the *volume* of acid, *i.e.* 10.0 cm^3 of HC*l*(aq) instead of 20.0 cm^3 of HC*l*(aq). **Note:** It is not possible to *halve* the *concentration* of HC*l*(aq). Although the volume of $H_2(g)$ would be halved, the reaction would also take place at a *slower rate*.

2. Study the graph for experiment **B**. In reaction **1**, 40.0 cm^3 of 2.0 mol/dm^3 hydrochloric acid was reacted with and excess of magnesium powder. What change(s) to this experiment would give the results observed in reaction **2**?

The rate of reaction **2** is *slower* than the rate of reaction **1**. The volume of H_2(g) produced by reaction **2** is the *same* as the volume of H_2(g) produced by reaction **1**. The volume of H_2(g) produced for reaction **1** and reaction **2** are the *same*, so moles of HC*l*(aq) – the limiting reagent – must be the *same* for both reactions. If the *concentration* of HC*l*(aq) is *halved* (1.0 mol/dm^3) to decrease the rate of reaction **2**, then the *volume* of HC*l*(aq) used must *double* (80.0 cm^3) to keep the moles of HC*l*(aq) constant for both reaction **1** and reaction **2** (remember, moles = $c \times v \times 10^{-3}$). Keeping the concentration and volume of HC*l*(aq) the same for reaction **1** and reaction **2**, the rate of reaction **2** could also be decreased by **a)** using magnesium *ribbon* instead of magnesium *powder*, **b)** performing reaction **2** at a *lower temperature* than reaction **1**.

3. Study the graph for experiment **C**. In reaction **2**, 20.0 cm^3 of 0.50 mol/dm^3 hydrochloric acid was reacted with an excess of magnesium ribbon. What change(s) to this experiment would give the results observed in experiment **1**?

The initial rate of reaction **1** is the *same* as the initial rate of reaction **2**. The volume of H_2(g) produced by reaction **1** is exactly *three times* the volume produced by reaction **2**. Moles of HC*l*(aq) – the limiting reagent – used for reaction **1** must be exactly *three times* the moles of HC*l*(aq) used for reaction **2**. This is achieved by using *three times* the *volume* of acid, *i.e.* 60.0 cm^3 of HC*l*(aq) instead of 20.0 cm^3 of HC*l*(aq). **Note:** It is not possible to *triple* the concentration of HC*l*(aq). Although the volume of H_2(g) would *triple*, the reaction would also take place at a *faster rate*.

4. Study the graph for experiment **D**. In reaction **1**, 20.0 cm^3 of 2.0 mol/dm^3 hydrochloric acid was reacted with an excess of magnesium ribbon. What change(s) to this experiment would give the results observed in experiment **2**?

The initial rate of reaction **2** is *faster* than the initial rate of reaction **1**. The volume of H_2(g) produced by reaction **2** is exactly *half* the volume produced by reaction **1**. Moles of HC*l*(aq) – the limiting reagent – used for reaction **2** must be exactly *half* the moles of HC*l*(aq) used for reaction **1**. This is achieved by using *half* the *volume* of acid, *i.e.* 10.0 cm^3 of HC*l*(aq) instead of 20.0 cm^3 of HC*l*(aq). The rate of reaction **2** can be made faster than the rate of reaction **1** by **a)** *increasing* the *temperature* of reaction **2** (a 10°C increase in temperature will double the rate of reaction), **b)** using *powdered* magnesium instead of magnesium *ribbon* for reaction **2**, **c)** adding a *catalyst* to reaction **2**.

Note: It is possible to *increase* the *concentration* of the acid to make the reaction faster, but the *volume* of acid used must be *reduced* in order to halve the volume of H_2(g) produced. For reaction **1**: moles of HC*l*(aq) = $2.0 \times 20.0 \times 10^{-3}$ = 0.0400 mol. For reaction **2**, moles of HC*l*(aq) must be $^1/_2 \times 0.0400$ = 0.0200 mol. A possible way of achieving this is to use 5.0 cm^3 of 4.0 mol/dm^3 acid, which would give $4.0 \times 5.0 \times 10^{-3}$ = 0.0200 mol.