labs

1.

$$N_2(g) + 3\,H_2(g) \rightleftarrows 2\,NH_3(g) \qquad \Delta H < 0$$

$NH_3(g)$ was synthesized at 200°C in the presence of a powdered Os(*s*) catalyst, leading to the equilibrium system represented above. Which of the following changes would result in more $NH_3(g)$ in the mixture after equilibrium is reestablished?

(A) Replacing the powdered Os(*s*) with a solid cube of Os(*s*) of the same total mass

(B) Increasing the temperature of the system to 250°C at constant pressure

(C) Removing some $H_2(g)$

(D) Adding some $N_2(g)$

2. To gravimetrically analyze the silver content of a piece of jewelry made from an alloy of Ag and Cu, a student dissolves a small preweighed sample in HNO_3(aq). Ag^+(aq)and Cu^{2+}(aq) ions form in the solution. Which of the following should be the next step in the analytical process?

(A) Centrifuging the solution to isolate the heavier ions

(B) Evaporating the solution to recover the dissolved nitrates

(C) Adding enough base solution to bring the pH up to 7.0

(D) Adding a solution containing an anion that forms an insoluble salt with only one of the metal ions

3.

$$2\,BaO_2(s) \rightleftarrows 2\,BaO(s) + O_2(g)$$

$$\Delta H° = 162 \text{ kJ/mol}_{rxn}$$

A sealed rigid vessel contains $BaO_2(s)$ in equilibrium with BaO(*s*) and $O_2(g)$ as represented by the equation above. Which of the following changes will increase the amount of $BaO_2(s)$ in the vessel?

(A) Removing a small amount of $O_2(g)$

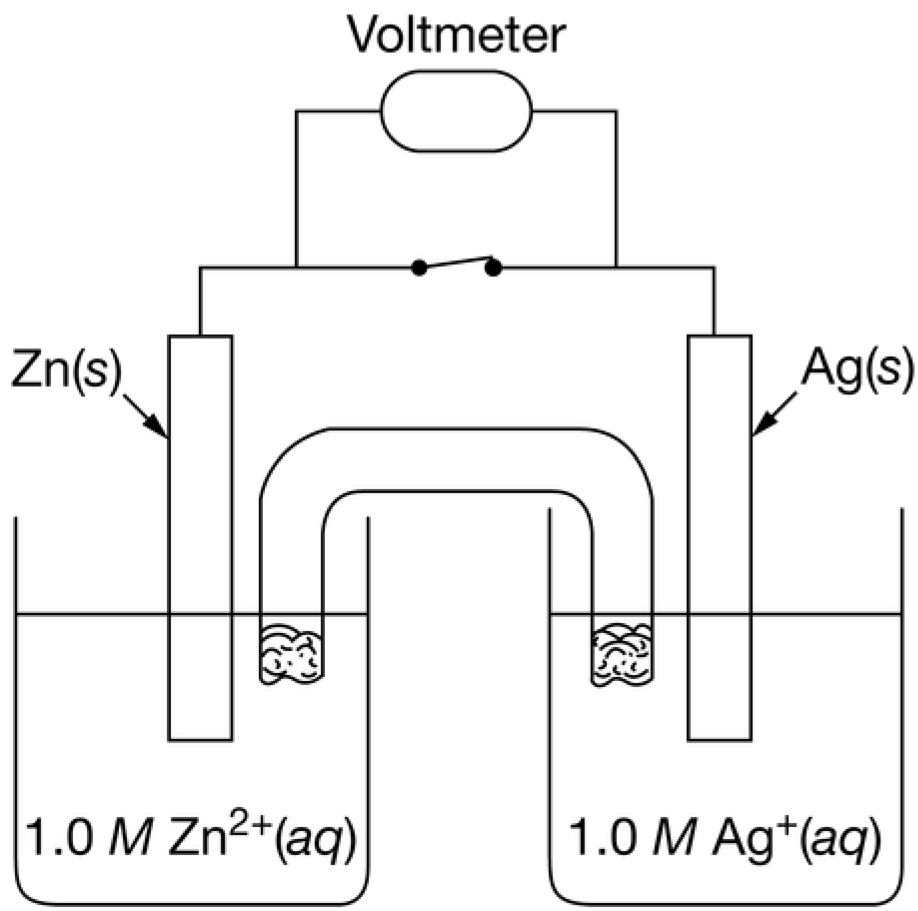
(B) Removing a small amount of BaO(*s*)

(C) Adding He gas to the vessel

(D) Lowering the temperature

labs

4.



Which of the following substances would be the best choice for filling the salt bridge in the galvanic cell shown above, and why?

(A) Distilled water, because it would avoid contaminating the solutions in the half-cells.

(B) $1.0\ M\ \mathrm{HCl}(aq)$, because it would acidify the solutions and catalyze the overall cell reaction.

(C) $1.0\ M\ \mathrm{CH_3OH}(aq)$, because it would increase the pH of the solutions and catalyze the overall cell reaction.

(D) $1.0\ M\ \mathrm{KNO_3}(aq)$, because the mobile ions would allow charge to flow between the half-cells.

5. Which of the following is the best piece of laboratory glassware for preparing 500.0 mL of an aqueous solution of a solid?

(A) Volumetric flask

(B) Erlenmeyer flask

(C) Test tube

(D) Graduated beaker

(E) Graduated cylinder

A $0.50\ \mathrm{g}$ sample of $\mathrm{Mg}(s)$ was placed in a solution of $\mathrm{HCl}(aq)$, where it reacted completely.

6. In another experiment, a small piece of $\mathrm{Mg}(s)$ is weighed, then placed in a flask containing excess $1\ M\ \mathrm{HCl}(aq)$. The student wants to determine number of moles of gas produced. Which of the following is the best way to conduct the experiment for accurate data collection?

(A) Conducting the experiment at different temperatures to see which generates the most gas

(B) Completing the entire reaction in a large Erlenmeyer flask of known volume to measure the volume of the gas collected

(C) Collecting the gas in a eudiometer tube and measuring the volume of the gas collected

(D) Conducting the reaction in a graduated cylinder and measuring the volume of the gas collected

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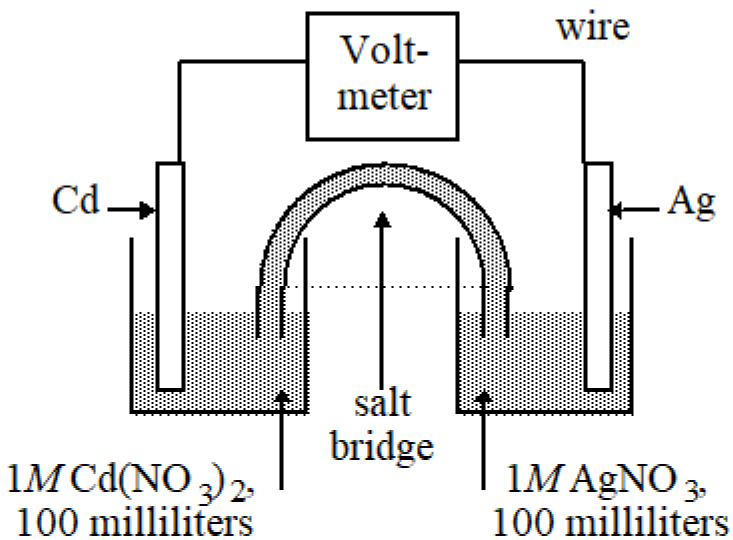
7.



The spontaneous reaction that occurs when the cell above operates is $2\ Ag^+ + Cd(s) \rightarrow 2\ Ag(s) + Cd^{2+}$

Which of the above occurs for the following circumstance?

A 50–milliliter sample of a 2-molar $Cd(NO_3)_2$ solution is added to the left beaker.

(A) Voltage increases.

(B) Voltage decreases but remains above zero

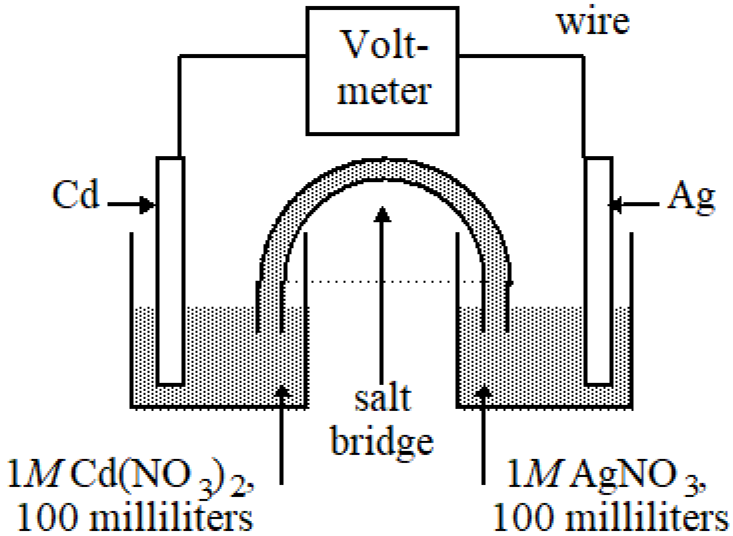
(C) Voltage becomes zero and remains at zero

(D) No change in voltage occurs

(E) Direction of voltage change cannot be predicted without additional information

labs

8.



The spontaneous reaction that occurs when the cell above operates is $2\ Ag^{+} + Cd(s) \rightarrow 2\ Ag(s) + Cd^{2+}$

Which of the above occurs for the following circumstance?

The silver electrode is made larger.

(A) Voltage increases.

(B) Voltage decreases but remains above zero

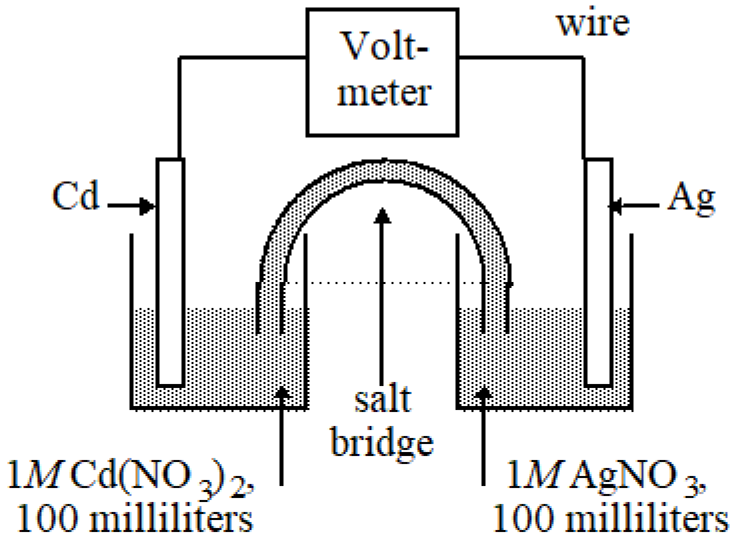
(C) Voltage becomes zero and remains at zero

(D) No change in voltage occurs

(E) Direction of voltage change cannot be predicted without additional information

labs

9.



The spontaneous reaction that occurs when the cell above operates is $2\ Ag^{+} + Cd(s) \rightarrow 2\ Ag(s) + Cd^{2+}$

Which of the above occurs for the following circumstance?

The salt bridge is replaced by a platinum wire.

(A) Voltage increases.

(B) Voltage decreases but remains above zero

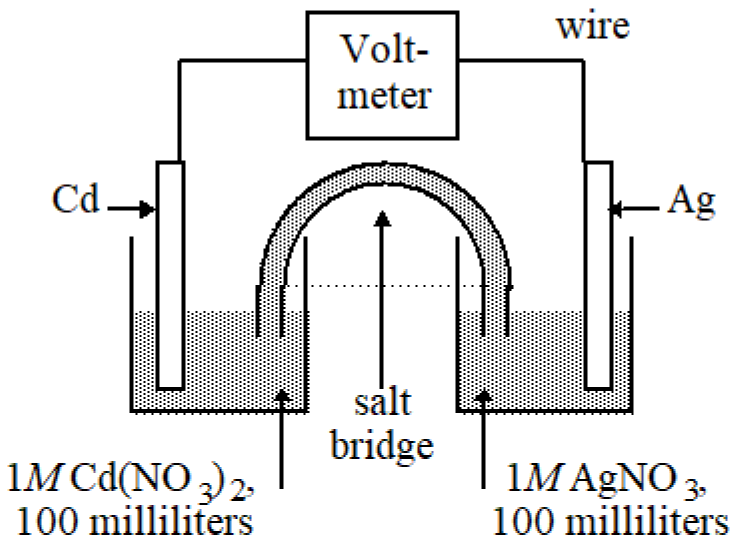
(C) Voltage becomes zero and remains at zero

(D) No change in voltage occurs

(E) Direction of voltage change cannot be predicted without additional information

labs

10.



The spontaneous reaction that occurs when the cell above operates is 2 Ag^+ + Cd(*s*) → 2 Ag(*s*) + Cd^{2+}

Which of the above occurs for the following circumstance?

Current is allowed to flow for 5 minutes

(A) Voltage increases.

(B) Voltage decreases but remains above zero

(C) Voltage becomes zero and remains at zero

(D) No change in voltage occurs

(E) Direction of voltage change cannot be predicted without additional information

11. Which of the following is a list of the minimum amount of data needed for determining the molar enthalpy of solution of $KCl(s)$ in pure $H_2O(l)$? (Assume that the $KCl(aq)$ has the same specific heat capacity as pure water and that the initial temperatures of the $KCl(s)$ and the water are the same.)

(A) Mass of $KCl(s)$, initial temperature of the water, and final temperature of the solution

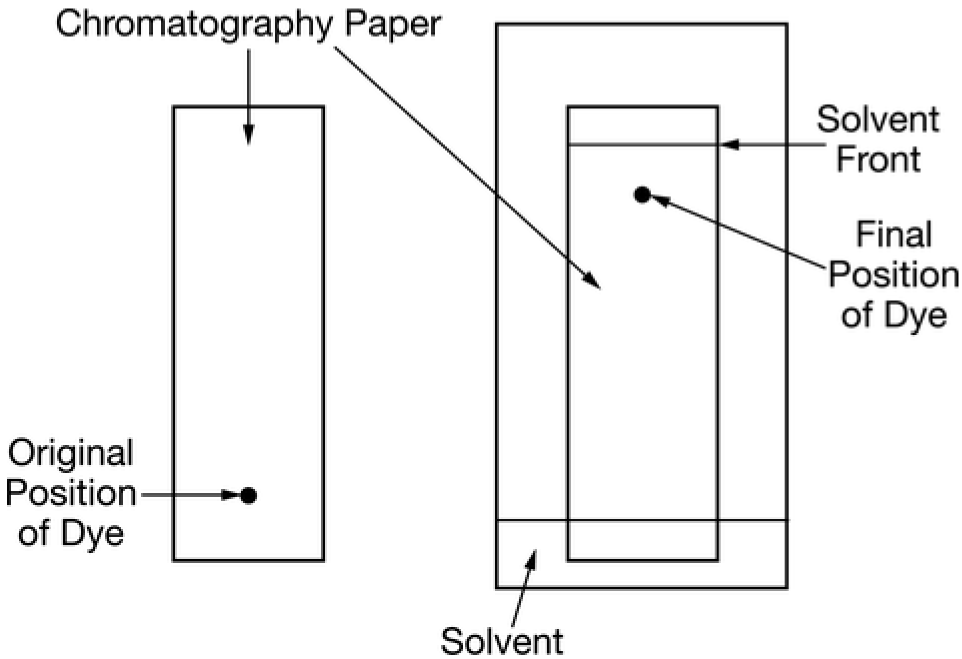
(B) Mass of H_2O, initial temperature of the water, and final temperature of the solution

(C) Mass of $KCl(s)$, mass of H_2O, initial temperature of the water, and final temperature of the solution

(D) Mass of $KCl(s)$, mass of H_2O, initial temperature of the water, final temperature of the solution, and atmospheric pressure

labs

12.



Based on the results of the paper chromatography experiment shown above, which of the following can be concluded about the dye?

(A) It has a small molar mass.

(B) It has weak intermolecular forces.

(C) It has a weaker attraction for the stationary phase that it has for the mobile phase.

(D) It has a stronger attraction for the stationary phase than it has for the mobile phase.

13. The percentage of silver in a solid sample is determined gravimetrically by converting the silver to $Ag^{+}(aq)$ and precipitating it as silver chloride. Failure to do which of the following could cause errors in the analysis?

I. Account for the mass of the weighing paper when determining the mass of the sample

II. Measure the temperature during the precipitation reaction

III. Wash the precipitate

IV. Heat the $AgCl$ precipitate to constant mass

(A) I only

(B) I and II

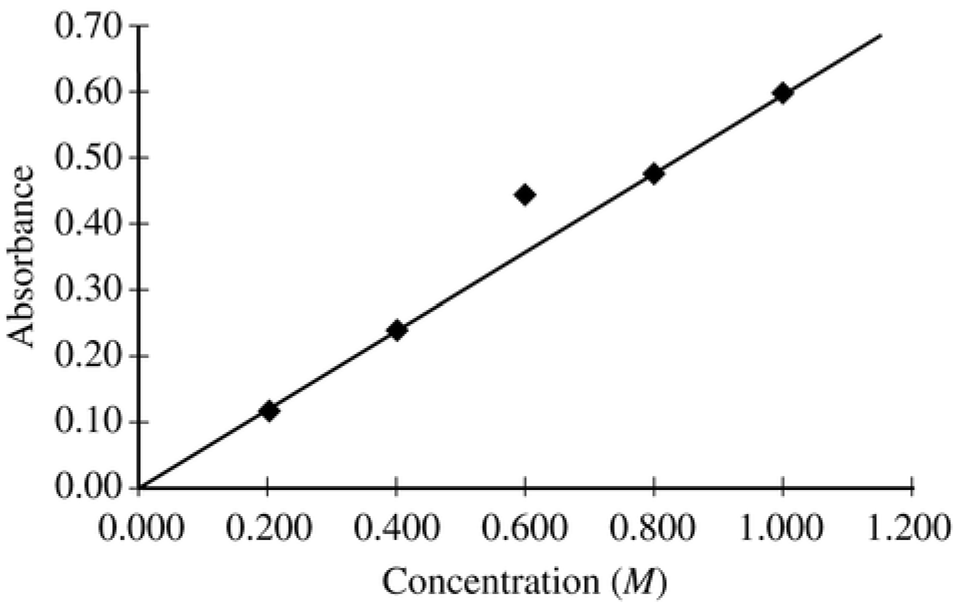
(C) I and IV

(D) II and III

(E) I, III, and IV

labs

14.



A student prepared five solutions of $CuSO_4$ with different concentrations, and then filled five cuvettes, each containing one of the solutions. The cuvettes were placed in a spectrophotometer set to the appropriate wavelength for maximum absorbance. The absorbance of each solution was measured and recorded. The student plotted absorbance versus concentration, as shown in the figure above. Which of the following is the most likely explanation for the variance of the data point for the 0.600 *M* $CuSO_4$ solution?

(A) The cuvette into which the 0.600 *M* solution was placed had some water droplets inside.

(B) The cuvette into which the 0.600 *M* solution was placed was filled slightly more than the other cuvettes.

(C) The wavelength setting was accidentally moved away from that of maximum absorbance.

(D) The cuvette used for the 0.600 *M* solution had not been wiped clean before being put in the spectrophotometer.

15. When 5.0 g of $NH_4ClO_4(s)$ is added to 100. mL of water in a calorimeter, the temperature of the solution formed decreases by 3.0°C. If 5.0 g of $NH_4ClO_4(s)$ is added to 1000. mL of water in a calorimeter initially at 25.0°C, the final temperature of the solution will be approximately

(A) 22.0°C

(B) 24.7°C

(C) 25.3°C

(D) 28.0°C

16. Which of the following pieces of laboratory glassware should be used to most accurately measure out a 25.00 mL sample of a solution?

(A) 5 mL pipet

(B) 25 mL pipet

(C) 25 mL beaker

(D) 25 mL Erlenmeyer flask

(E) 50 mL graduated cylinder

labs

17. A kinetics experiment is set up to collect the gas that is generated when a sample of chalk, consisting primarily of solid $CaCO_3$, is added to a solution of ethanoic acid, CH_3COOH. The rate of reaction between $CaCO_3$ and CH_3COOH is determined by measuring the volume of gas generated at $22^{o}C$ and 1 atm as a function of time. Which of the following experimental conditions is most likely to increase the rate of gas production?

(A) Decreasing the volume of ethanoic acid solution used in the experiment

(B) Decreasing the concentration of the ethanoic acid solution used in the experiment

(C) Decreasing the temperature at which the experiment is performed

(D) Decreasing the particle size of the $CaCO_3$ by grinding it into a fine powder

18. In an experiment to estimate the enthalpy change of a reaction, a student makes two aqueous solutions, each containing one of the reactants. The student combines the solutions, both originally at the same temperature, in a calorimeter and records the final temperature of the mixture. In addition to the masses of the solutions and the temperature change of the mixture, which of the following pieces of information does the student need to calculate the enthalpy change of the reaction?

(A) The density of the reaction mixture

(B) The specific heat capacity of the reaction mixture

(C) The boiling point of the reaction mixture

(D) The heat of fusion of the reaction mixture

19. To determine the percentage of water in a hydrated salt, a student heated a 1.2346 g sample of the salt for 30 minutes; when cooled to room temperature, the sample weighed 1.1857 g. After the sample was heated for an additional 10 minutes and again cooled to room temperature, the sample weighed 1.1632 g. Which of the following should the student do next?

(A) Use the smallest mass value to calculate the percentage of water in the hydrated salt.

(B) Repeat the experiment with a new sample of the same mass and average the results.

(C) Repeat the experiment with a new sample that has a different mass.

(D) Reheat the sample until its mass is constant.

(E) Use the average of the mass values obtained after the two heatings to calculate the percentage of water in the hydrated salt.

20. When a buret is rinsed before a titration, which of the techniques below is the best procedure?

(A) Rinse the buret one time with some of the titrant solution.

(B) Rinse the buret one time with some of the titrant solution and then dry the buret in an oven.

(C) Rinse the buret two times: once with some of the titrant solution, then once with distilled water.

(D) Rinse the buret two times: each time with some of the titrant solution.

(E) Rinse the buret two times: each time with distilled water.

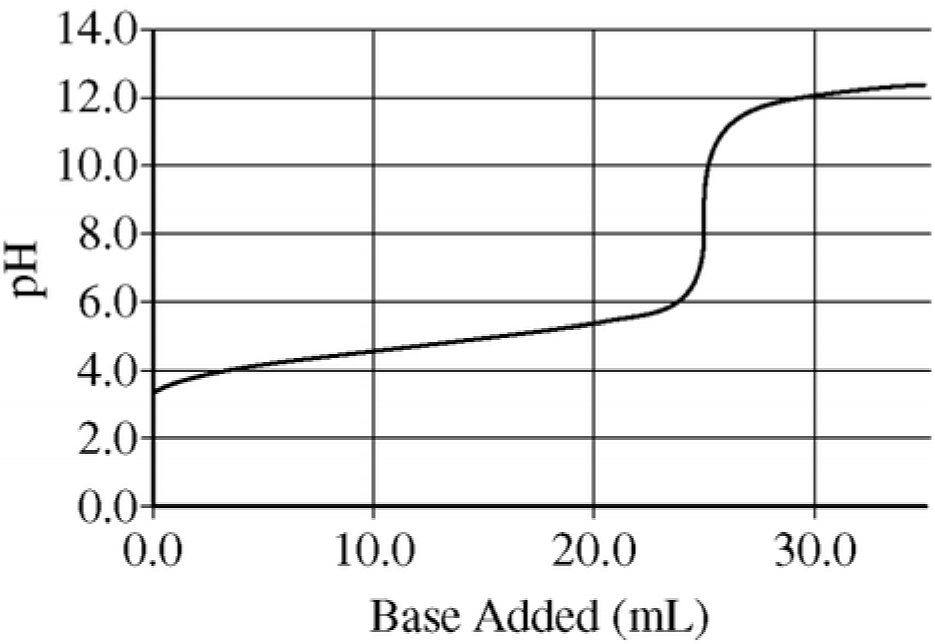
21. For an experiment, a student needs 100.0 mL of 0.4220 M NaCl. If the student starts with NaCl(s) and distilled water, which of the following pieces of laboratory glassware should the student use to prepare the solution with the greatest accuracy?

labs

(A) 25 mL volumetric pipet
(B) 100 mL Erlenmeyer flask
(C) 100 mL graduated cylinder
(D) 100 mL volumetric flask
(E) 1 L beaker

A 0.35 g sample of Li(*s*) is placed in an Erlenmeyer flask containing 100 mL of water at 25°C. A balloon is placed over the mouth of the flask to collect the hydrogen gas that is generated.

After all of the Li(*s*) has reacted with $H_2O(l)$, the solution in the flask is added to a clean, dry buret and used to titrate an aqueous solution of a monoprotic acid. The pH curve for this titration is shown in the diagram below



22. Which of the following changes will most likely increase the rate of reaction between Li(s) and water?

(A) Using 125 mL of water instead of 100 mL
(B) Using a 0.25 g sample of Li(*s*) instead of a 0.35 g sample
(C) Using a 0.35 g sample of Li(*s*) cut into small pieces
(D) Decreasing the water temperature before adding the Li(*s*)

23. What will be the effect on the amount of gas produced if the experiment is repeated using 0.35 g of K(*s*) instead of 0.35 g of Li(*s*) ?

labs

(A) No gas will be produced when K(s) is used.

(B) Some gas will be produced but less than the amount of gas produced with Li(s).

(C) Equal quantities of gas will be produced with the two metals.

(D) More gas will be produced with K(s) than with Li(s).

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24. A student is given a sample of a pure, white crystalline substance. Which of the following would be most useful in providing data to determine if the substance is an ionic compound?

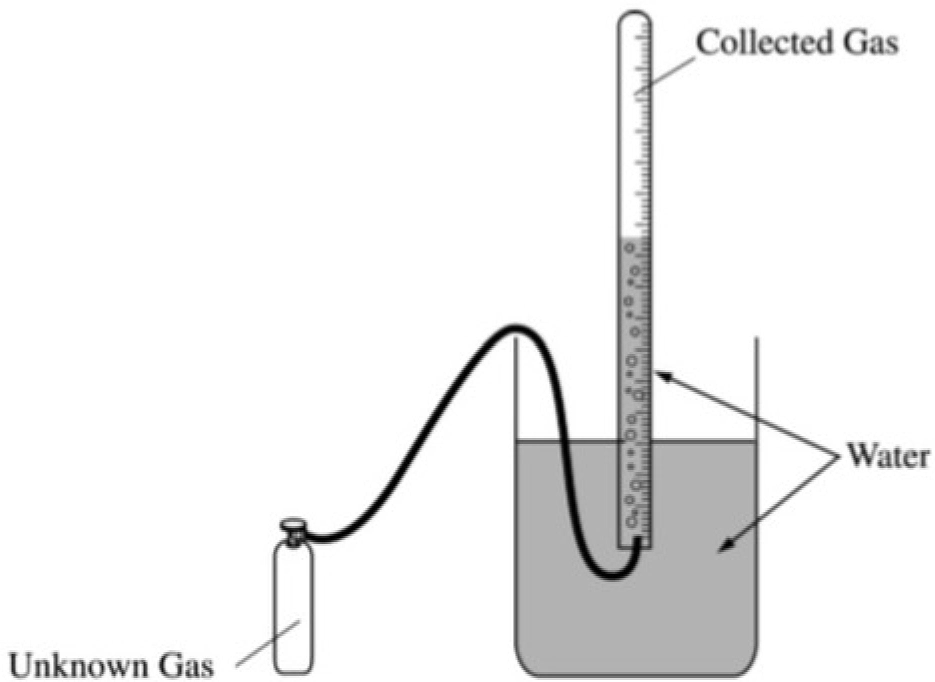
(A) Examining the crystals of the substance under a microscope

(B) Determining the density of the substance

(C) Testing the electrical conductivity of the crystals

(D) Testing the electrical conductivity of an aqueous solution of the substance

25.



A sample of an unknown gas from a cylinder is collected over water in the apparatus shown above. After all the gas sample has been collected, the water levels inside and outside the gas collection tube are made the same. Measurements that must be made to calculate the molar mass of the gas include all of the following EXCEPT

(A) atmospheric pressure

(B) temperature of the water

(C) volume of gas in the gas-collection tube

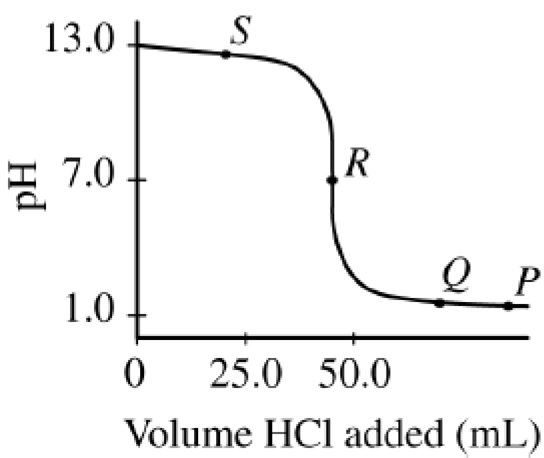
(D) initial and final mass of the gas cylinder

(E) mass of the water in the apparatus

labs

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

To determine the concentration of a NaOH(*aq*) solution, a student titrated a 50. mL sample with 0.10 *M* HCl(*aq*) . The reaction is represented by the equation above. The titration is monitored using a pH meter, and the experimental results are plotted in the graph below.



26. One student titrated the NaOH(*aq)* with 1.0 M HCl(aq) instead of 0.10 *M* HCl(aq) . How would the student's titration curve differ from the original curve?

(A) The initial pH would be 11 instead of 13.

(B) The pH at the equivalence point would be 5 instead of 7.

(C) The pH far beyond the equivalence point would be higher than in the original curve.

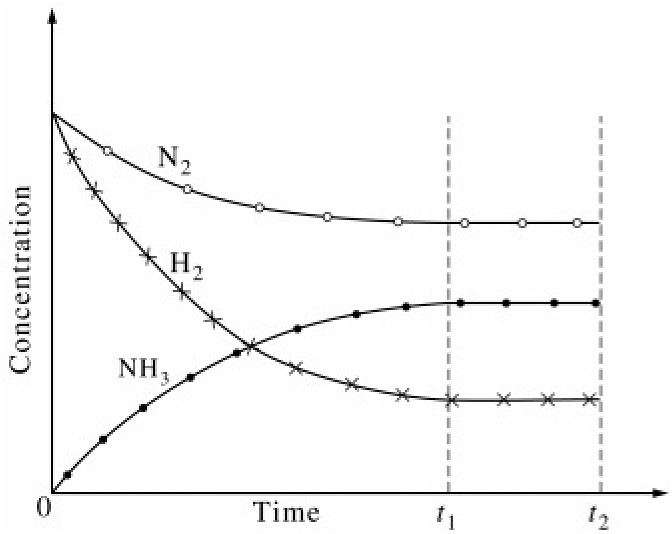
(D) The pH far beyond the equivalence point would be lower than in the original curve.

labs

H_2 gas and N_2 gas were placed in a rigid vessel and allowed to reach equilibrium in the presence of a catalyst according to the following equation.

$$3\ H_2(g) + N_2(g) \rightleftarrows 2\ NH_3(g) \qquad \Delta H^{\circ} = -92\ \text{kJ/mol}_{rxn}$$

The diagram below shows how the concentrations of H_2 , N_2 , and NH_3 in this system changed over time.



27. More NH_3 gas is added to the system at time t_2 while the temperature is held constant. Which of the following will most likely occur?

(A) The value of the equilibrium constant will increase

(B) The value of the equilibrium constant will decrease.

(C) The total pressure in the container will decrease.

(D) The amount of N_2 will increase.

(E) The amount of H_2 will decrease.

$2\ NO_2(g) \rightleftarrows N_2O_4(g)$

dark brown colorless

The dimerization of $NO_2(g)$, an exothermic process, is represented by the equation above.

28. Which of the following experimental techniques will allow the most accurate determination of the concentration of $NO_2(g)$ at equilibrium?

labs

(A) Paper chromatography
(B) Gravimetric analysis
(C) Titration
(D) Spectrophotometry

29.

Compound	K_{sp} at 298 K
Ag_2SO_4	1×10^{-5}
$PbSO_4$	1×10^{-8}

A 1.0 L solution $AgNO_3(aq)$ of and $Pb(NO_3)_2(aq)$ has a Ag^+ concentration of 0.020 M and a Pb^{2+} concentration of 0.0010 M. A 0.0010 mol sample of $K_2SO_4(s)$ is added to the solution. Based on the information in the table above, which of the following will occur? (Assume that the volume change of the solution is negligible.)

(A) No precipitate will form.
(B) Only $Ag_2SO_4(s)$ will precipitate.
(C) Only $PbSO_4(s)$ will precipitate.
(D) Both $Ag_2SO_4(s)$ and $PbSO_4(s)$ will precipitate.

30. Reaction A: $4\ HCl(g) + O_2(g) \rightleftarrows 2\ Cl_2(g) + 2\ H_2O(g)$

Reaction B: $N_2O_4(g) \rightleftarrows 2\ NO_2(g)$

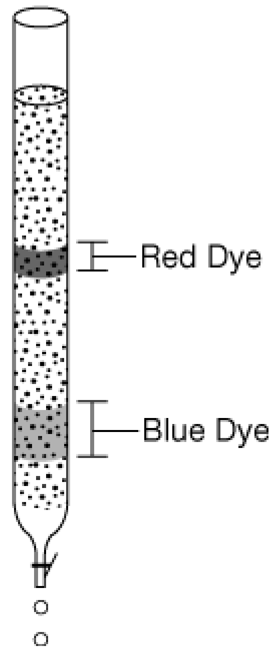
Reaction C: $H_2(g) + I_2(g) \rightleftarrows 2\ HI(g)$

Reaction D: $2\ NH_3(g) \rightleftarrows N_2(g) + 3\ H_2(g)$

The reactions represented above are carried out in sealed, rigid containers and allowed to reach equilibrium. If the volume of each container is reduced from 1.0 L to 0.5 L at constant temperature, for which of the reactions will the amount of product(s) be increased?

(A) Reaction A
(B) Reaction B
(C) Reaction C
(D) Reaction D

labs



A student placed a sample of a food coloring that contains a mixture of a blue dye and a red dye at the top of a chromatography column filled with a nonpolar stationary phase. When water is poured through the column, two bands of colors are seen in the column, as shown in the diagram above.

31. A student collects a sample of the blue dye from the column in a cuvette. Which of the following is least useful to determine the concentration of the sample using a spectrophotometer set at $640 \mathrm{~nm}$?

(A) The volume of the sample

(B) The path length of the cuvette

(C) The absorbance of the dye at $640 \mathrm{~nm}$

(D) The molar absorptivity of the dye at $640 \mathrm{~nm}$

32. Which of the following will most likely be observed if $\mathrm{CH_3OH}(l)$ is used in the column instead of water? (Assume that both solvents flow through the column at the same rate.)

(A) The dyes will not pass through the column because $\mathrm{CH_3OH}(l)$ is a nonpolar solvent.

(B) The dyes will pass through the column at a slower rate because $\mathrm{CH_3OH}(l)$ is a less polar solvent than water.

(C) The dyes will pass through the column at a faster rate because $\mathrm{CH_3OH}(l)$ has a greater molar mass than water.

(D) No differences will be observed because the polarity of the solvent does not affect the separation of the dyes.

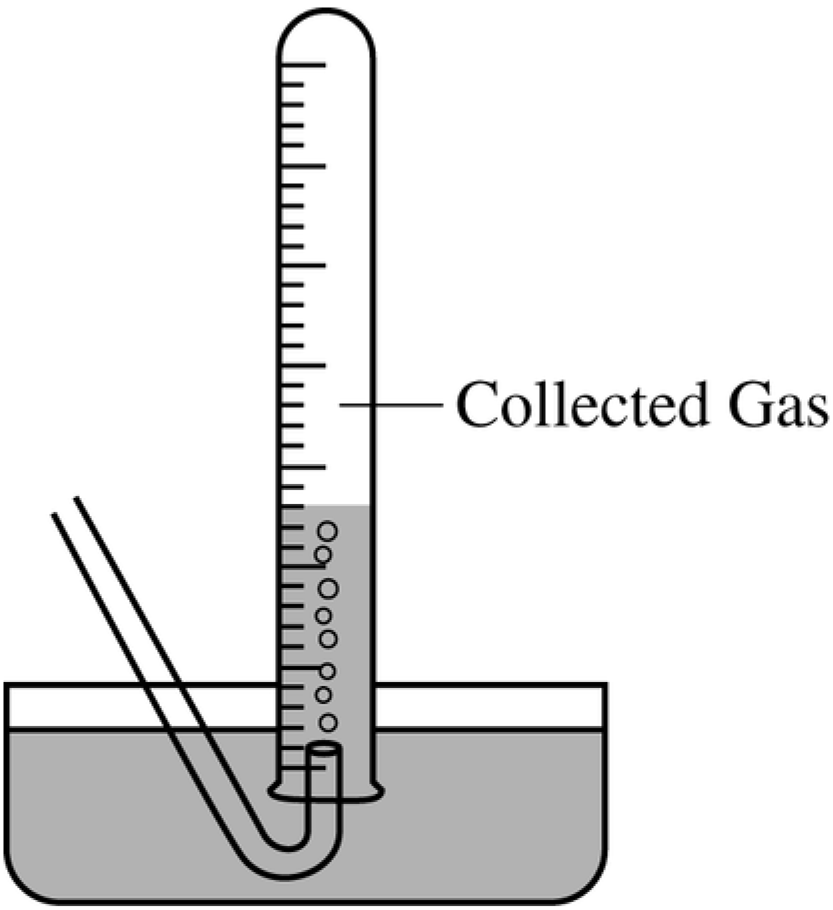
---

33. Which of the following techniques is most appropriate for the recovery of solid KNO_3 from an aqueous solution of KNO_3?

labs

(A) Paper chromatography
(B) Filtration
(C) Titration
(D) Electrolysis
(E) Evaporation to dryness

34.



Gases generated in a chemical reaction are sometimes collected by the displacement of water, as shown above. Which of the following gases can be quantitatively collected by this method?

(A) H_2
(B) CO_2
(C) HCl
(D) SO_2
(E) NH_3

35. A kinetics experiment is set up to collect the gas that is generated when a sample of chalk, consisting primarily of solid $CaCO_3$, is added to a solution of ethanoic acid, CH_3COOH. The rate of reaction between $CaCO_3$ and CH_3COOH is determined by measuring the volume of gas generated at 25^oC and 1 atm as a function of time. Which of the following experimental conditions is most likely to increase the rate of gas production?

labs

(A) Decreasing the volume of ethanoic acid solution used in the experiment

(B) Decreasing the concentration of the ethanoic acid solution used in the experiment

(C) Decreasing the temperature at which the experiment is performed

(D) Decreasing the particle size of the $CaCO_3$ by grinding it into a fine powder