BRAINIACS OLYMPIAD

GRADES 9-10

CHEMISTRY SAMPLE PAPER
(PRACTICAL PART)

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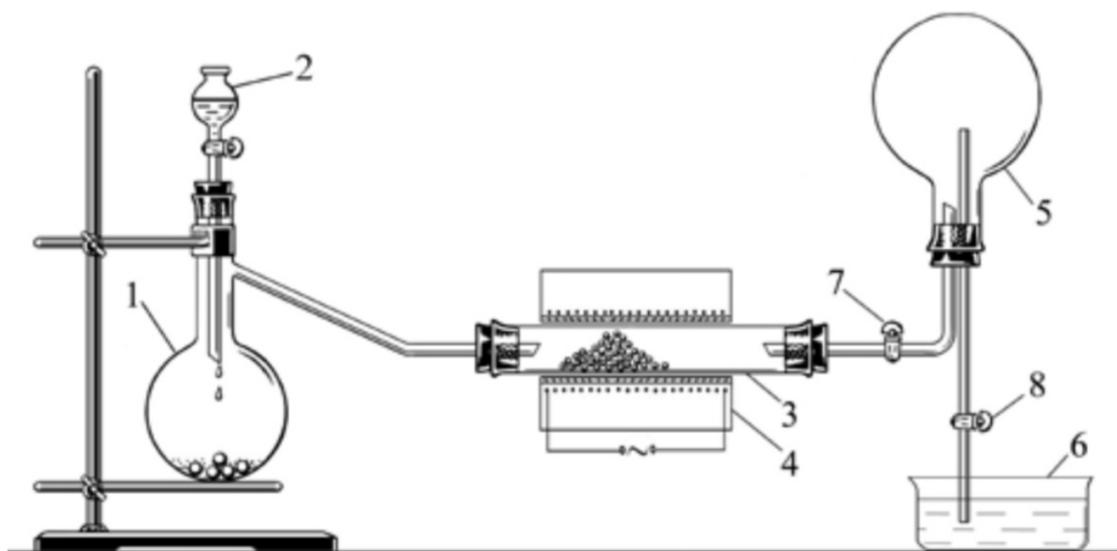
CHEMISTRY SAMPLE PAPER-PRACTICAL PART
Grade: 9-10
Time: 120 minutes
Total points: 100
Equipment: Not required

TASK 1 (50 points)
"Fountain" With and Without Iron

In a Wurtz flask (labeled 1 in the diagram), a mixture of aluminum powder, sodium hydroxide, and sodium nitrate was placed. Water was added to the mixture from the dropping funnel (2), and intensive gas evolution began in the reaction mixture. The gases were passed through tube (3).

The gases filled flask (5), displacing the air from it. After flask (5) became filled with gas, stopcock (7) was closed and stopcock (8) was opened. Water began to rise through the tube from the bath (6) into flask (5), and a "fountain" effect occurred. Water filled flask (5) to about half.

At the next stage of the experiment, the procedure was repeated in the same apparatus and with the same mass of the initial mixture. However, this time the gases released from flask (1) were heated in tube (3) using the electric furnace (4), and pieces of porous iron were placed in tube (3). After the gases returned to the initial conditions in flask (5), stopcock (7) was closed and stopcock (8) was opened again. The water level rose from the bath (6) into flask (5), but this time flask (5) was filled with water only to one quarter.

Questions

1. Which gases were released in flask (1) upon addition of water? Provide the corresponding chemical equations. A mixture contains 2.70 g of aluminum. It reacts completely with NaOH. Calculate the volume of hydrogen gas (at STP) produced. (10 points)

2. Sodium nitrate oxidizes part of the aluminum. If 0.10 mol $NaNO_3$ is added, how many moles of NH_3 will form? What fraction of total gas (hydrogen and ammonia) does NH_3 represent? (10 points)

3. In the first experiment the fountain fills the flask halfway (1.0 L). The temperature of the gas inside before opening is 350 K, volume 2.0 L, pressure 1.5 atm. After opening, pressure becomes atmospheric (1.0 atm). Calculate a) how many moles of gas escaped, b) how many moles remain, c) why the water volume corresponds to exactly half the flask (show using the ideal gas law). (14 points)

4. Why did a "fountain" occur in flask (5) after stopcock (8) was opened? Why did the flask fill only halfway with water, and not completely? (6 points)

5. What color will the liquid in flask (5) turn if phenolphthalein is added beforehand to the water in bath (6)? Why? (4 points)

6. Propose a possible explanation for the fact that heating the gases released from flask (1) in the presence of iron leads to a change in the composition of the gas mixture. This is evidenced by the smaller amount of water that rose from the bath (6) into flask (5) during the second experiment. It is advisable to support your answer with a chemical equation. (6 points)

TASK 2 (50 points)

Measuring pH Change During Neutralization
Neutralization is a reaction where an acid and a base react to form salt and water.It happens when H^+ from the acid combines with OH^- from the base to make H_2O.
You will investigate how the pH of a solution of ethanoic acid changes as sodium hydroxide is added. Ethanoic acid is a weak acid; NaOH is a strong base.

Materials provided:
• 25.0 cm³ of 0.100 mol·dm⁻³ CH_3COOH (pipetted accurately)
• NaOH solution of unknown concentration in a burette (students must determine concentration from titration data below)
• Burette (2.0 cm³ increments available), pipette, beaker, magnetic stirrer or glass rod, pH meter (or calibrated universal indicator + colour chart), thermometer, stopwatch.

Procedure:
7. Calibrate the pH meter (or check indicator colors against standards). Record calibration check.

8. Place the 25.0 cm³ acid in a beaker. Start with the pH measured and recorded.

9. Add NaOH in successive 2.0 cm³ portions from the burette. After each addition: stir thoroughly, allow pH reading to stabilise (≤10 s), then record the pH and cumulative volume added. Continue adding until at least 20.0 cm³ have been added (or until pH > 12), recording pH after each 2.0 cm³ addition.

10. Plot a pH vs. volume graph from your recorded results and use it to locate the equivalence point. Use the graph to estimate: the equivalence volume (Veq) and the pH at equivalence.

11. Answer the questions below using your recorded data and the graph.

Questions

A)

(i) Present your recorded data in a clear table (volume added, pH).

(ii) Plot pH vs. volume (graph paper / software). Label axes, include points and a smooth curve.

(iii) Using the graph, determine and state the equivalence volume Veq (to nearest 0.1 cm³). Explain briefly how you found it.

B)

Given: initial acid = 25.0 cm³ of 0.100 mol·dm⁻³ CH₃COOH.

(i) Calculate the initial moles of CH₃COOH.

(ii) Use your measured Veq to calculate the concentration of NaOH in the burette. Show working.

(iii) If you added 20.0 cm³ NaOH, calculate the moles of excess OH⁻ and the pH of the final solution. Assume total volume = (25.0 + 20.0) cm³. Show working and state any approximations.

C)

(i) Explain why the equivalence pH for a weak acid + strong base titration is greater than 7.

(ii) Suggest a suitable indicator for this titration and justify your choice with reference to its colour-change pH range.

(iii) Predict qualitatively how the pH-volume graph would change if the acid used were strong (HCl) at the same concentration.

(iv) If the ethanoic acid concentration were halved to 0.050 mol·dm⁻³ (same initial volume 25.0 cm³), predict quantitatively how Veq would change.