Destructive Distillation of Carbon

Introduction:
Elemental carbon is a polymorphic substance; the forms are diamond, graphite, and buckminsterfullerene. Coke, charcoal, and carbon black are commercially available impure forms of carbon. Coke and charcoal are readily prepared by the destructive distillation of coal and wood, respectively.

Destructive distillation differs from ordinary distillation in that the substances first decompose at a high temperature, and part or all of the decomposition products then distills. When coal is heated out of air, complex compounds of carbon undergo decomposition to form such substances as benzene, toluene, naphthalene, anthracene, phenol, etc. These pass off as a vapor and are condensed into a liquid called coal tar by cooling. Because the boiling point of carbon is extremely high, the carbon that is present in coal, or that is formed by decomposition, is left as a residue. Carbon prepared in this manner is called coke. When a ton of soft coal is destructively distilled, there results about 1500 pounds of coke, 140 pounds of coal tar, and 10,000 cubic feet of coal gas (CO, H₂, CH₄), and ammonia (NH₃).

When wood is heated out of air, the complex carbon compounds undergo decomposition to form volatile products and a residue of carbon called charcoal. Neither coke nor charcoal is pure carbon. The mineral content originally present in the coal or wood is still present in the coke or charcoal.

The most important volatile products resulting from the distillation of wood are methyl alcohol, CH₃OH, acetone, (CH₃)₂CO, and acetic acid, CH₃COOH.

Experimental:
Destructive Distillation of Coal. Set-up the apparatus shown below.

[Diagram of distillation apparatus with text instructions]
“A” is a 6-inch test tube and “B” may be a small 2 or 4 fluid ounce bottle. Water in the beaker cools and condenses the vapors. Half fill tube “A” with coal and heat strongly. From time to time while heating, test the gas escaping from jet “C” with a burning splint. Continue heating until no further change occurs. Note the appearance of the liquid which condenses in the bottle. When test tube “A” cools, remove the residue and examine it.

**Destructive Distillation of Wood.** Remove the coke from test tube “A” and the liquid from bottle “B”. Repeat the experiment using wood instead of coal. Do not use new equipment. Check to see if a combustible gas is evolved. Note the appearance and amount of the liquid which condenses in bottle “B”. Examine the residue.

**Properties of Carbon:**

**Action on Acids and Bases.** Try to dissolve a small lump of charcoal or coal in about 3 mL of a strong acid like hydrochloric. Repeat, using a strong base like sodium hydroxide.

**Reduction.** Thoroughly mix 3 grams of cupric oxide with 0.5 grams of powdered charcoal on your watch glass. Transfer the mixture to a test tube and clamp the test tube vertically on a ring stand. Heat the test tube gently at first, then with a strong hot flame. Test for the evolution of carbon dioxide by using a burning splint. Does the residue look like copper?

**Adsorption.** Dissolve a tiny pinch of methylene blue (about the size of the head of a pin) in about 25 mL of water. Add about 2 grams of boneblack or some other finely divided carbon. Heat, stirring rapidly, until the boiling point is reached. Filter and observe the appearance of the filtrate.
Report for Experiment:

*Destructive Distillation of Coal*

1. Is the gas combustible? __________
2. Write the equation for the combustion of methane.
3. Write the equation for the combustion of carbon monoxide.
4. What are the names of the five substances probably present in the coal tar?
   (1) ____________  (2) ____________  (3) ____________  
   (4) ____________  (5) ____________
5. What is the common name for the residue?
6. What element makes up most of the residue?

*Destructive Distillation of Wood*

7. Is the gas combustible? __________
8. What was the appearance of the distillate?
9. How much distillate did you collect?
10. What are the names of the three substances probably present in the distillate?
   (1) ___________  (2) ___________  (3) ___________

11. What is the name of the residue?

Action on Acids and Bases

12. Results of lump of coal or charcoal in hydrochloric acid?

13. Results of lump of coal or charcoal in sodium hydroxide?

Reduction

14. Was the test for CO₂ positive?

15. What was the appearance of the residue after heating?

16. Write the redox equation that took place between the carbon and cupric oxide. Label the reducing and oxidizing agents.

Adsorption

17. What was the appearance of the filtrate?

18. How do you explain the results in terms of colloidal material and adsorption?