Unit 11 · Phenol

WORKSHEET

Full marks 37

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 37

1 Key words [4]

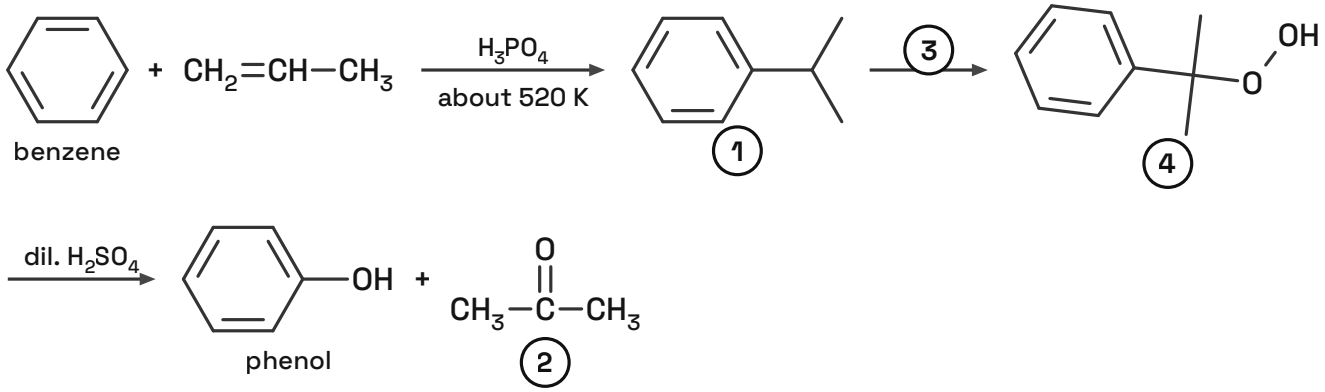
Fill in the blanks with words from the box. Two words in the box are not needed. Each blank carries 0.5 mark.

anisole	Bakelite	cumene	Kolbe's	novolac	phenolphthalein	phenoxide
Reimer–Tiemann	salicylic acid	violet				

Nearly all the world's phenol is made from _____, with acetone as the second product. Phenol is a weak acid because the _____ ion it forms is stabilized by resonance. Sodium phenoxide heated with carbon dioxide under pressure gives _____ in _____ reaction. Phenol warmed with chloroform and NaOH gets a –CHO group at its ortho position in the _____ reaction. Heated with phthalic anhydride, phenol gives the indicator _____. Phenol and methanal give a hard thermosetting plastic, _____, and with neutral iron(III) chloride phenol gives a _____ color.

2 Label the diagram [2]

The diagram shows the cumene process. Write what belongs in place of 1 to 4. Each carries 0.5 mark.



1. _____ 2. _____

3. _____ 4. _____

3 Multiple choice [5]

Choose the correct option for each of the following questions.

i. The order of acidic strength is: [1]

a. ethanol > water > phenol
b. water > phenol > ethanol
c. phenol > water > ethanol
d. phenol > ethanol > water

ii. Which is the strongest acid? [1]

a. 4-methylphenol
b. phenol
c. 3-nitrophenol
d. 4-nitrophenol

iii. Phenol heated with zinc dust gives: [1]

a. benzene
b. cyclohexanol
c. sodium phenoxide
d. 1,4-benzoquinone

iv. 2-Nitrophenol can be separated from 4-nitrophenol by steam distillation because 2-nitrophenol: [1]

a. is a stronger acid
b. has a hydrogen bond inside its own molecule, so its molecules hold each other less
c. is a solid
d. reacts with steam

v. Phenol with bromine in CS_2 in the cold gives mainly: [1]

a. 2,4,6-tribromophenol
b. 4-bromophenol
c. 3-bromophenol
d. bromobenzene

4 Short answers [11]

Write short answers to the following questions.

a. Write balanced equations for the preparation of phenol i. from benzenesulphonic acid and ii. from anisole. [2]

b. Why does phenol dissolve in NaOH solution but give no carbon dioxide with $NaHCO_3$ solution? [2]

c. Why is chlorobenzene so hard to turn into phenol, and what conditions does Dow's process use? [2]

d. Write the equation for Kolbe's reaction, and say how its product is turned into aspirin. [2]

e. Describe three tests that tell phenol from ethanol, with what you would see. **[3]**

5 Long answer **[4]**

Write a long answer to the following question.

Explain, with the help of resonance, why phenol is more acidic than ethanol, and why its –OH group makes the ring react faster with electrophiles at the ortho and para positions. Illustrate with the reaction of phenol with bromine water.

6 Numerical problems **[8]**

Solve the following problems. Show your working. Take H = 1, C = 12, O = 16, Br = 80, the molar volume of a gas at STP as 22.4 L, and the pKa of phenol as 10.0.

a. A plant makes phenol from 1.00 tonne of cumene, $C_6H_5CH(CH_3)_2$, by the cumene process. i. Write the overall change from cumene and oxygen to the two products. ii. Find the masses of phenol and acetone at 100% yield. iii. Find the volume of oxygen (at STP) used. iv. Find the mass of phenol if the yield is 90%. **[4]**

Answer:

b. 0.94 g of phenol is dissolved in water and bromine water is added until no more reacts. i. Write the equation. ii. Find the mass of bromine used and of precipitate formed. iii. Find the pH of a 0.010 M phenol solution. iv. 4-Nitrophenol has pKa 7.15: about how many times stronger an acid is it than phenol (pKa 9.99)? **[4]**

Answer: _____

7 Think [3]

Friedel–Crafts alkylation of phenol gives a poor yield, although phenol's ring is strongly activated. Why? How does the same idea explain why phenol is acylated on its oxygen, and how can the acyl group be moved onto the ring?

8 Activity: Phenol bingo (not marked)

Phenol burns skin: this activity is done on paper. Make a 3 × 3 grid. In each square write one reagent from the unit (bromine water, neutral $FeCl_3$, NaOH, Na, zinc dust, CO_2 under pressure, $CHCl_3$ + NaOH, phthalic anhydride, methanal). Swap grids with a partner, who writes the product of phenol with each.

Reagent	Product with phenol	Name of the reaction or test

Which three of your products are used in everyday life?