Unit 15 · Thermoelectric Effect

WORKSHEET

Full marks 33

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 33

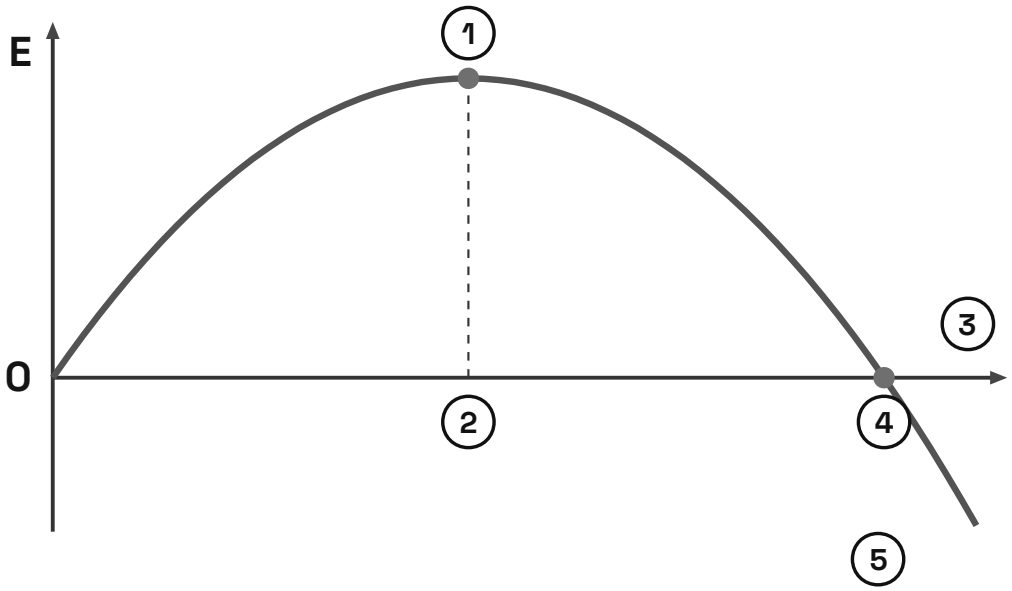
1 Key words [2.5]

Match each term in Column A with its meaning in Column B. One item in Column B is not needed. Each pair carries 0.5 mark.

Column A		Column B
1. Seebeck effect	☐	**a.** heat given out at one junction of a thermocouple and absorbed at the other when a current is passed
2. Peltier effect	☐	**b.** the temperature of the hot junction at which the thermo e.m.f. is greatest
3. neutral temperature	☐	**c.** the temperature of the hot junction at which the thermo e.m.f. becomes zero and then reverses
4. temperature of inversion	☐	**d.** an e.m.f. set up in a loop of two different metals whose junctions are at different temperatures
5. thermopile	☐	**e.** heat produced in a wire whichever way the current flows
		f. thermocouples joined in series to detect and measure heat radiation

2 Label the graph [2.5]

The graph shows how the thermo e.m.f. of a copper–iron thermocouple changes with the temperature of its hot junction, the cold junction kept at 0 °C. Write the label that belongs in place of 1 to 5. Each carries 0.5 mark.



1. _____ **2.** _____

3. _____ **4.** _____

5. _____

3 Multiple choice [5]

Choose the correct option for each of the following questions.

i. A thermocouple is made of zinc and nickel. Zinc comes before nickel in the thermoelectric series. The current flows: [1]

a. from zinc to nickel through the cold junction
b. from nickel to zinc through the cold junction
c. from zinc to nickel through the hot junction
d. either way, depending on which wire is longer

ii. For the same small difference of temperature between the junctions, which of these thermocouples gives the largest e.m.f.? [1]

a. silver–gold **b.** copper–platinum
c. iron–nickel **d.** tin–lead

iii. A thermocouple has a neutral temperature of 250 °C. With its cold junction at 20 °C, its temperature of inversion is: [1]

a. 230 °C **b.** 500 °C
c. 480 °C **d.** 520 °C

iv. The thermo e.m.f. of a thermocouple, with its cold junction at 0 °C, is $E = a\theta + b\theta^2$, where a = 30 μV/°C and b = −0.075 μV/°C^2. Its neutral temperature is: [1]

a. 200 °C **b.** 400 °C
c. 100 °C **d.** 0.0025 °C

v. How does the heat of the Peltier effect at a junction differ from Joule heating in the wires? **[1]**

a. Both are proportional to the square of the current.

b. The Peltier heat is proportional to the current and changes sign when the current is reversed; Joule heat is proportional to its square and always heats.

c. The Peltier heat always heats; Joule heat can cool.

d. The Peltier heat does not depend on the current.

4 Short answers **[6]**

Write short answers to the following questions.

a. Why does a loop made of two copper wires give no current, however hot one of its junctions is? **[2]**

b. The neutral temperature of a thermocouple does not depend on the temperature of its cold junction, but its temperature of inversion does. Explain. **[2]**

c. In a thermopile, why are i. antimony and bismuth used, and ii. one set of junctions coated with lamp black? **[2]**

5 Long answer [4]

Write a long answer to the following question.

The thermo e.m.f. of a thermocouple with its cold junction at 0 °C is $E = \alpha\theta + \frac{1}{2}\beta\theta^2$. Find expressions for its neutral temperature and its temperature of inversion. Hence show that with the cold junction at θ_c, the neutral temperature lies halfway between θ_c and the temperature of inversion.

6 Numerical problems [10]

Solve the following problems. Show your working.

a. [4]

The thermo e.m.f. of a thermocouple, with its cold junction at 0 °C, is $E = \alpha\theta + \frac{1}{2}\beta\theta^2$, with $\alpha = 12$ μV/°C and $\beta = -0.05$ μV/°C^2. Find i. its neutral temperature, ii. its temperature of inversion, iii. the greatest e.m.f. it can give, and iv. its e.m.f. with the hot junction at 100 °C.

Answer:

b. [3]

A chromel–alumel (type K) thermocouple gives about 41 μV for each degree of difference between its junctions. Its cold junction is at 25 °C, and it reads 24.6 mV with its hot junction inside a kiln. Find the temperature inside the kiln, taking the e.m.f. as proportional to the difference.

Answer:

c. A thermopile has 50 thermocouples in series, each giving 0.10 mV for each degree of difference between its junctions. Sunlight warms its blackened junctions to 1.2 °C above the shielded ones. Find i. the e.m.f. of the thermopile, and ii. how many thermocouples it would need to give 9.0 mV for the same warming. **[3]**

Answer: _____

7 Think **[3]**

Swastika uses the thermocouple of the first numerical problem ($E = 12\theta - 0.025\theta^2$ μV, cold junction at 0 °C) as a thermometer. It reads 0.95 mV, and she says the hot junction is at 100 °C. Could it be at any other temperature? What does this tell you about using a thermocouple as a thermometer?

8 Activity: Seeing the Seebeck effect (Activity 15.1) (not marked)

Twist a copper wire and an iron wire together at one end, and join their other ends to a digital multimeter on its millivolt range. Hold the junction at the places in the table and read the meter.

The junction	Reading (mV)
in the room	
above a candle flame	
in the flame	
out of the flame, a minute later	
in ice	

How does the reading depend on the temperature of the junction? What happened in ice?