

Period 7 Exercise Answers

E.1 Which one of the following statements is TRUE?

- a) In any physical process that uses energy to do work, all the energy will be transformed into useful work if we wait long enough.
- b) If we could construct a frictionless heat engine we could then transform all the energy we put into the heat engine into useful work.
- c) In any physical process that uses energy to do work, some of the energy we put into the system can never be transformed into useful work.
- d) NONE of the above statements is true.

E.1 = c

Note: statement b) – that the heat engine could operate with 100% efficiency – would be true only if the low temperature was zero Kelvin.

$$\text{eff} = \frac{T_H - T_L}{T_H} = \frac{293 - 0}{293} = \frac{293}{293} = 1.00$$

E.2 A gas exerts a pressure of 100 N/m^2 on the walls of its container. The temperature of the gas increases from 200 kelvin to 400 kelvin, while the volume of the container and the number of gas molecules remains the same. What pressure does the heated gas exert on the container?

a) 50 N/m^2

b) 100 N/m^2

c) 200 N/m^2

d) 400 N/m^2

e) Not enough information is given to answer the question.

Initially,

$$P = \frac{NkT}{V} = 100 \text{ N/m}^2$$

After the temperature doubles from 200K to 400K,

$$P = \frac{Nk \mathbf{2T}}{V} = \mathbf{2}(100 \text{ N/m}^2) = 200 \text{ N/m}^2$$

E.2 = c

E.3 Theoretically, the maximum possible efficiency of a heat engine operating between 400K and 200K is

- a) 10%
- b) 20%
- c) 25%
- d) 50%
- e) 100%

$$Eff = \frac{T_H - T_L}{T_H} = \frac{400 \text{ K} - 200 \text{ K}}{400 \text{ K}} = \frac{200 \text{ K}}{400 \text{ K}} = 0.5$$

E.3 = d

E.4 A power station has been proposed to operate on the Gulf Stream between the warm surface (at a temperature of 26 °C or 299 K) and the cool water at the bottom (at a temperature of 6 °C or 279 K). The maximum theoretical thermal efficiency of such a power station is

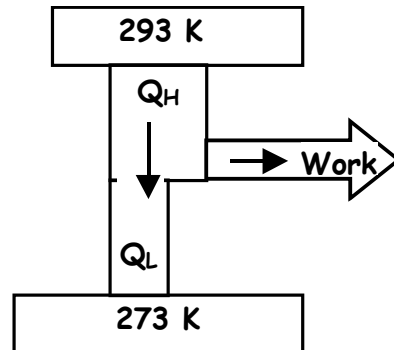
- a) greater than 25%.
- b) equal to 25%.
- c) less than 25%.
- d) impossible to calculate since more information is needed.

$$Eff = \frac{T_H - T_L}{T_H} = \frac{299 \text{ K} - 279 \text{ K}}{299 \text{ K}} = \frac{20 \text{ K}}{299 \text{ K}} = 0.067$$

E.4 = c

E.5 Find the efficiency of the ideal device illustrated in the diagram.

- a) 1.07%
- b) 6.8%
- c) 7.3 %
- d) 50%
- e) 93%



$$\text{eff} = \frac{T_H - T_L}{T_H} = \frac{293 - 273}{293} = \frac{20}{293} = 0.068$$

E.5 = b

E.6 Which device could the diagram in question E.5 represent?

- a) a heat pump
- b) a heat engine
- c) a refrigerator
- d) an air conditioner
- e) both c) and d)

E.6 = b

E.7 If you place an operating air conditioner in the center of an insulated room, the room will

- a) become cooler.
- b) not change in temperature.
- c) become warmer.
- d) become either warmer or cooler depending on the efficiency of the air conditioner.

E.7 = c

E.8 A heat pump is a device that heats a room mainly by

- a) transferring thermal energy from a hotter object to a cold object.
- b) converting thermal energy into electrical energy.
- c) pumping hot water into the room.
- d) transferring thermal energy from a colder object to a hotter object.
- e) using thermal energy to pump electricity into a heater.

E.8 = d

E.9 Suppose the outside temperature is 2 °C and the indoor temperature is 22 °C. Then the maximum theoretical (coefficient of) performance of a heat pump operating under such conditions is

- a) less than 1.
- b) greater than 1.
- c) impossible to determine from the above information.

Convert from Celsius degrees to Kelvin:

$$T_H = 22 + 273 = 295 \text{ K}$$

$$T_L = 2 + 273 = 275 \text{ K}$$

$$COP = \frac{Q_H}{W} = \frac{T_H}{T_H - T_L} =$$

$$\frac{295 \text{ K}}{295 \text{ K} - 275 \text{ K}} = \frac{295 \text{ K}}{20 \text{ K}} = 14.74$$

E.9 = b

Period 7 Answers

E.1 = c

E.2 = c

E.3 = d

E.4 = c

E.5 = b

E.6 = b

E.7 = c

E.8 = d

E.9 = b