L3D1

THE INSTITUTION OF FIRE ENGINEERS
Founded 1918 • Incorporated 1924

IFE Level 3 Diploma in Fire Science and Fire Safety

Unit 1: Fire Engineering Science (A/505/6005)

Friday 13 March 2020

10.30 – 13.30

Instructions to Candidates

1. The time allowed for this examination is **THREE** hours.

2. Candidates must answer **SIX** questions from the total of **EIGHT** questions set for this examination.

3. All questions carry equal marks and may be answered in any order. Candidates should follow the instructions provided in the question when composing their answers.

4. Candidates should record all of their answers in the answer book provided.

5. The question paper must be handed in with the answer book.

Question 1

a)

i) With regards to electricity flowing in a circuit, define the following terms and state the units of each:

- current
- voltage

(4 marks)

ii) Explain the relationship between voltage and current in a circuit.

(2 marks)

b) A High Rupture Capacity (HRC) fuse may be used in an electrical circuit.

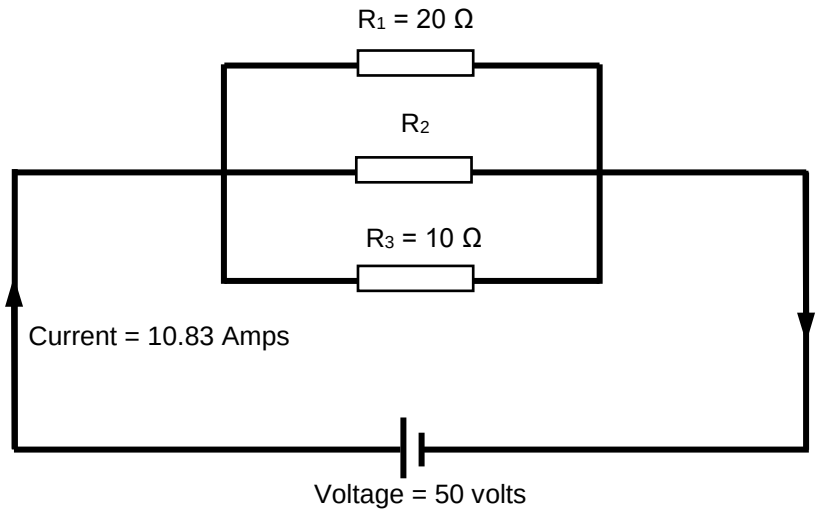
i) Explain the function and operation of an HRC fuse.

(4 marks)

ii) Sketch a diagram of an HRC fuse and label the main component parts.

(4 marks)

c) Consider the following circuit.



i) Calculate the value of resistor R_2.

(2 marks)

ii) Calculate the total resistance in the circuit. Ignore the resistance of the cables.

(2 marks)

iii) Calculate the total power being drawn from the supply.

(2 marks)

Question 2

a) With reference to the SI system:

i) explain what is meant by the term “base units”.

(2 marks)

ii) identify any three base units.

(3 marks)

iii) explain the term “derived units”.

(2 marks)

b) Explain the following terms:

i) elastic deformation

(2 marks)

ii) plastic deformation

(2 marks)

iii) yield point

(2 marks)

c) Young’s modulus for a given steel is 196GPa. Calculate the extension of a steel wire 4.5 m long with a cross-sectional area 1.0×10^{-3} cm^2 when the wire is stretched by a load of 0.8 kg. (Take g to equal 9.81 m/s^2)

(7 marks)

Question 3

a) Explain the principle and components of the fire tetrahedron.

(5 marks)

b) Explain the difference between flaming and smouldering combustion.

(6 marks)

c) Name and give the simple chemical formulae for the first three members of the alkane group and describe the trend in their relative melting points, boiling points and densities.

(9 marks)

[Please turn over]

Question 4

a) A firefighting jet of water is flowing from a 25mm nozzle on a branch at the end of a line of 70mm delivery hose. The water pressure at the nozzle is 4 bar. If the water stream is projected vertically, calculate the maximum height at which an effective firefighting stream could be expected. Use the following formula for your calculation:

$H_e = \frac{2}{3}\left(H - 0.113\frac{H^2}{d}\right)$ Where $H = 10P$ (which is the max theoretical height without practical losses)

(4 marks)

b) Calculate the maximum height that any droplets of water from the jet in part a) might reach and explain why this is greater than the height of the effective firefighting stream.

(6 marks)

c) As water flows through a line of hose, frictional losses will cause a reduction in pressure. List five factors that describe how energy is lost due to friction.

(5 marks)

d) If the flow of water through the nozzle in part a) above is 650 litres per minute, and the line of hose feeding it comprises 7 x 25 metre lengths (friction factor 0.005 per length), calculate the pressure at the pump. Assume that there is no difference in height between the pump and the branch.

(5 marks)

Question 5

a) Explain what is meant by the term *coefficient of superficial expansion* for a particular material. State the formula for finding this coefficient and explain the terms.

(3 marks)

b) Describe Boyle's Law. State the formula and explain the terms.

(3 marks)

c) Describe three methods by which heat can transfer from one place to another.

(9 marks)

d) A pressurised aerosol can is at a pressure of 3 bar and a temperature of 20°C. If the can explodes in a fire when it reaches a temperature of 1,150°C, what would be the pressure in the can at the point of explosion? Assume that the volume of the can remains constant when heated. Show all formulae and calculations used

(5 marks)

Question 6

a) Materials can respond in three ways to radiant energy. Describe these possible responses.

(6 marks)

b) Briefly describe the difference between non-ionising and ionising radiation and identify one type of non-ionising radiation and one type of ionising radiation.

(4 marks)

c) Define the following terms:

i) half-life

(2 marks)

ii) radioactive decay

(2 marks)

iii) isotope

(2 marks)

d) Briefly describe the two different categories of damage ionising radiation can cause to biological cells.

(4 marks)

Question 7

a) Describe the properties and hazards of carbon monoxide.

(6 marks)

b) Write a balanced chemical equation for the incomplete combustion of methane.

(4 marks)

c) The production of carbon monoxide is one physical characteristic of combustion that provides an operating principle for detectors. Another characteristic is flame. Describe the forms of radiant energy in a flame and explain how they are detected to produce a fire alarm.

(10 marks)

[Please turn over]

Question 8

a) With regards to fire pumps, define the following terms:

i) pump

(2 marks)

ii) water power

(2 marks)

iii) brake power

(2 marks)

iv) pump efficiency

(2 marks)

b) A pump discharges 2000 litres of water per minute at 6 bar pressure.

i) Calculate the water power of the pump.

(3 marks)

ii) If the pump is 70% efficient, calculate the brake power of the engine driving the pump.

(4 marks)

iii) If the design of the pump were to be improved so that the discharge increased to 2400 litres of water per minute at 6 bar, calculate the new efficiency of the pump.

(3 marks)

c) Explain why a pump could never be 100% efficient in practice.

(2 marks)