IFE Level 4 Certificate in Fire Science and Fire Safety

Unit 1 – Fire Engineering Science

Examiner Report – March 2020

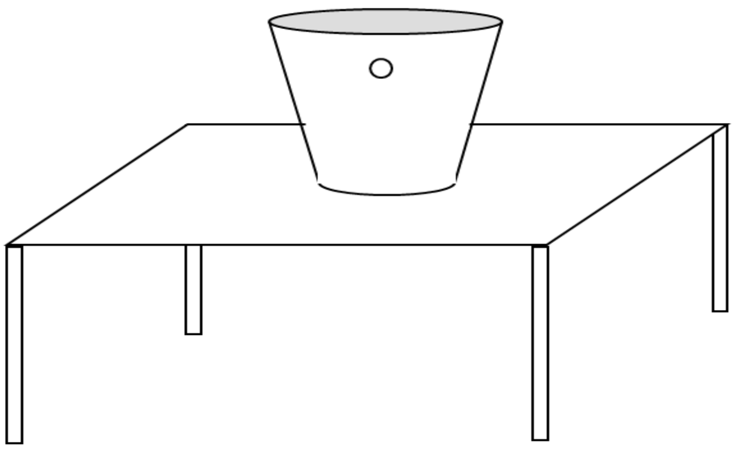
Introduction

50 candidates sat this examination. Pass rates were poor with only 12% of the candidates securing a pass.

The senior examiner noted that candidates appeared to be unprepared and that candidates who failed the examination usually attained fewer than 20% of the available marks. It was also notable that candidates often had good understanding of one or two subject areas and it was common for candidates to score marks of 15-19 on some questions but significantly lower marks on others depending on which subjects they had studied in most detail.

Many candidates omitted to convert data into SI Units. This is an essential requirement in order to make the equations make sense. As marks are awarded for the use of correct units, candidates who omit the units in their answer are unable to attain the allocated marks.

Question 1



Refer to the diagram above. A plastic container, 60cm high and open at the top, is filled with foam concentrate and placed on top of a table which is 1.3m from the floor. The container *has a top diameter of 30cm and a bottom diameter of 15cm. A circular hole of 1.5cm diameter is made in the side of the container such that its centre is 20cm from the top. (Density of foam concentrate = 850kgm^{-3})*

Complete the calculations below, working in SI units and answering complete to 3 significant figures (s.f).

a) Calculate the mass of foam concentrate in the container. (5 marks)

b) Use Bernoulli's theorem to calculate the velocity of the foam concentrate as it escapes through the hole. (8 marks)

c) Assuming constant flow, calculate how long it will take before the container stops leaking. Ignore any reduction in velocity caused by viscosity. (7 marks)

Examiner Feedback

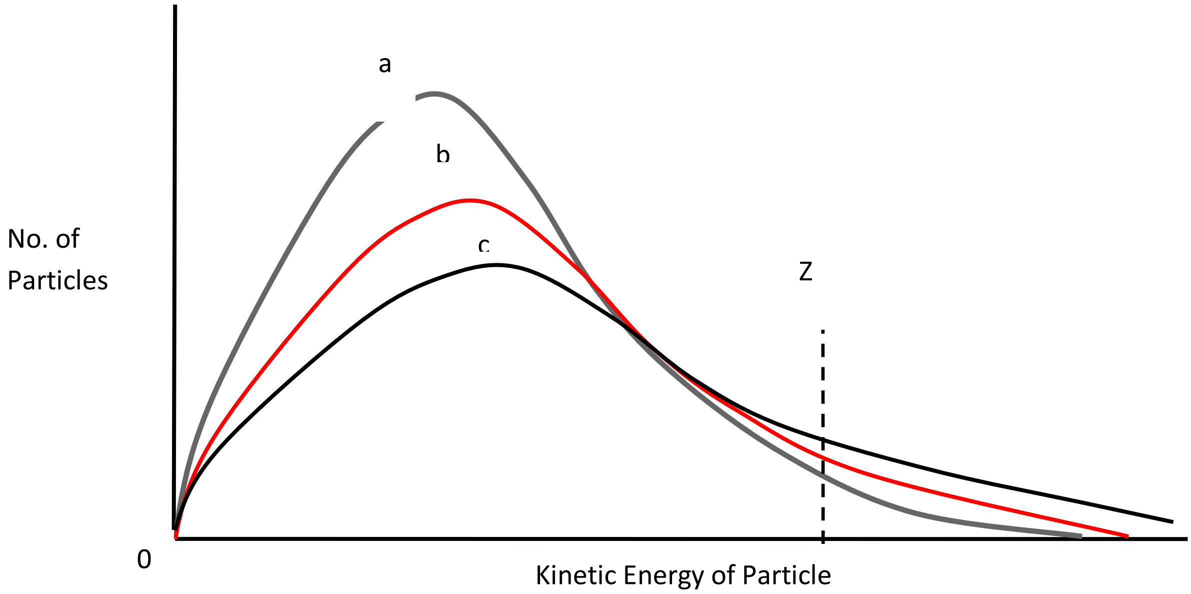
This question was a popular option for candidates. However, few candidates performed well and the average mark attained for this question was 4. One candidate provided an excellent response and secured 19 marks.

Part a) was often answered poorly. The majority of candidates failed to visualise the container as a sloping cylinder and therefore they failed to take the average of the top and bottom areas multiplied by the height, using the same familiar method used to calculate the volume of a sloping swimming pool. The answer to the question was: mass of foam in container = 21.4kg Part b) of the question required a Bernoulli calculation which could be much simplified by eliminating pressure and density which remained constant and could therefore be ignored. Many candidates produced long, clumsy equations that became confusing. The failure to convert to SI Units not only missed marks but led to the use of inappropriate formulae later in the question. The correct response to part b) was $V_1 = 1.98\, m/s$

Part c) required a straightforward calculation. The correct answer was that it would take 34.24 seconds to stop leaking.

<u>Question 2</u>

a) Explain what is meant by "activation energy". How does it affect the flammability of a substance? (3 marks)



The graph above is referred to as the Maxwell – Boltzmann Distribution Curve.

b) Describe the curves that are showing. (5 marks)

c) State the variable that changes between the curves a, b and c on the graph. (2 marks)

d) Explain why each curve passes through the coordinates 0,0. (2 marks)

e) State what is indicated by point Z and explain how each curve differs at this point and the significance of that. (4 marks)

f) Referring to the graph, describe what would be the effect of adding a catalyst to the reaction. (4 marks)

Examiner Feedback

The average mark attained for this question was four. However, one candidate secured 16 marks.

Few candidates demonstrated that they understood that activation energy is a concept relevant to all chemical reactions and not just combustion.

In relation to the Maxwell – Boltzmann Distribution Curve, very few candidates explained correctly what the curves represent. The majority of candidates presented irrelevant descriptions of fire initiation, growth and decay. The curves plot the number of particles in a chemical reaction with a particular kinetic energy. The area under each curve represents the total number of particles. The three different curves represent a change in one variable but the areas under each curve remain equal ie same overall number of particles. The shape would also be the same for gases, liquids and solids although the numbers would differ.

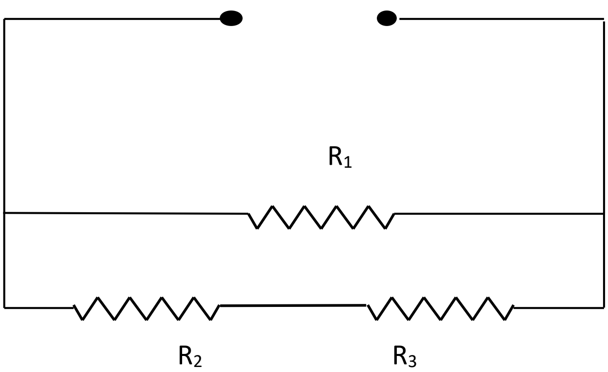
Question 3

The photograph below shows an electrical installation that is commonly found in rural areas.

a) *Name and briefly describe the parts labelled in the photograph above as A to E.*

(5 marks)

b)



Three resistors are placed in an electrical circuit with a 230V_p (peak voltage) supply as shown in the figure above. Resistor 1 has an average power rating of 2.5kW, resistor 2 has a resistance of 21.26Ω, and resistor 3 has an average power rating of 4kW. The total peak current flowing in the circuit is 15A. Consider only pure resistance in the circuit, ignoring any reactance.

Calculate the following:

- *i) the value of the peak current flowing through resistor 3.* *(5 marks)*
- *ii) the resistance of resistor 1.* *(5 marks)*
- *iii) the resistance of resistor 3.* *(3 marks)*
- *iv) the average power rating of resistor 2.* *(2 marks)*

Examiner Feedback

Candidates generally performed best on this question. The highest mark attained for this question was 17.

Part a) was usually answered well and many candidates were able to identify most, if not all, of the parts in the diagram.

The calculations required by part b) required a basic understanding of Ohms Law and a systematic approach to solving a circuit problem. Although most candidates appeared to recognise this as an Ohms law problem, failure to follow a systematic method led to errors and limited the marks that candidates could obtain.

Question 4

An insulated spherical vessel with a 4m diameter is filled with ammonia gas to a pressure of 2.5 atm. Take the density of ammonia to be 0.73kg/m^3 at 1atm and 20^{o}C and the gas constant to be 8.314, atomic mass nitrogen = 14, hydrogen = 1

a) Calculate the density of the gas inside the vessel once filled. *(2 marks)*

b)

- *i) Use the Gas Laws to calculate the temperature of the gas inside the vessel at equilibrium.* *(10 marks)*
- *ii) Describe the assumption you made in your calculation above.* *(2 marks)*

c) If an internal heating element is used to increase the temperature of the gas by 20^{o}C, calculate the new pressure inside the vessel. *(6 marks)*

Examiner Feedback

Problems involving the Gas Laws at this level require the application of two equations. Both of the equations required for this question are provided on the formula sheet ie PV = nRT and P1V1/ T1 = P2V2/T2. One of these equations includes a term that relates to molar mass and the number of moles of a substance; only one candidate demonstrated an understanding of these terms and how to use them. The majority of candidates who attempted the question generally secured only low marks.

Failure to convert to SI units was again a major stumbling block to gaining good marks.

Question 5

a) *Explain what is measured in Becquerels.* *(2 marks)*

b) *What is the Sievert and what does it measure?* *(2 marks)*

c) *Explain the connection, and the difference between, the Gray and the Sievert.* *(2 marks)*

d) *Explain the term "effective dose" and state how it is calculated.* *(2 marks)*

e) *State and explain two reasons why it is not a straightforward process to calculate how much radiation is received from an isotope source of known strength.* *(4 marks)*

f) *Thorium 230 has a half life, $t_{1/2}$, of 8×10^4 years. Sketch a graph using four calculated data points to show how the isotope decays over time.* *(8 marks)*

Examiner Feedback

The first parts of this question were designed to test understanding of the units commonly used in measuring different aspects of ionising radiation. Most candidates appeared to rely on a basic knowledge of time/distance and shielding which is insufficient for this level of examination.

Part f) of the question required the sketching of a graph to show the decay of an isotope given only its half-life. This was generally well answered with many candidates scoring full marks.

Question 6

a) *Explain how and why spontaneous smouldering may occur in oil-soaked pipe lagging.* *(5 marks)*

b) *Explain how the autoignition temperature of a hydrocarbon changes with increase in molecular weight.* *(2 marks)*

c) *Explain how spontaneous ignition may occur with rags that have been used to wipe paint brushes or spills.* *(5 marks)*

d) *Compare the situation in part c) with that in part a) and explain the difference.* *(5 marks)*

e) *Some solid fuels, for example coal, are capable of spontaneous ignition. Explain three factors that affect the likelihood of spontaneous combustion occurring in coal.* *(3 marks)*

Examiner Feedback

This was one of the most popular questions on the examination with most of the candidates who sat the examination attempting it. Although the average mark attained (4) was low, there were some very good responses with the highest mark achieved being 15.

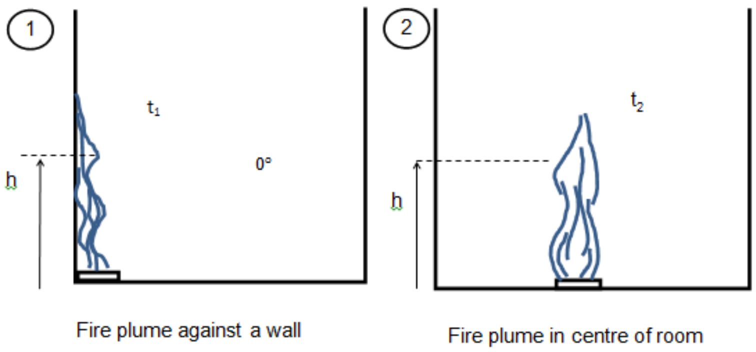
The question concerned two different situations in which spontaneous ignition can occur; candidates were required to describe both situations and to then distinguish between them. At this level, candidates should be able to describe the chemistry that underpins these well-documented phenomena. However, few candidates referred to energy transfer within systems and few understood why increase an in molecular weight will result in a decrease in auto ignition temperature.

Question 7

a) Orientation is one factor that affects the rate of spread of flame in solids. Identify and explain five additional factors. *(15 marks)*

b) Consider the two situations below. They each show the free burning of identical materials in identical rooms. Situation 1 shows burning against a non-combustible wall; in situation 2, the fire is in the centre of the room. There is no limit to the amount of oxygen available for combustion.

Compare the temperatures t_1 and t_2 of the flame taken at the same height, h, and at the same time in the fire's development in each case. Explain your answer. *(5 marks)*



Examiner Feedback

This question was a popular option with most candidates attempting it.

The question required an understanding of surface spread of flame. Most candidates referenced ignition, flammability and combustion which attracted few marks. Many candidates correctly identified ventilation as an important factor in the spread of flame without mention of the specific reasons for its importance such as oxygen concentration or flame deflection. The factors that could have been covered in responding to part a) were:

- thickness of the fuel
- density, thermal capacity, thermal conductivity.
- geometry of the sample:
- presence of edges
- composition of the atmosphere
- fuel temperature
- atmospheric pressure
- imposed air movement

Question 8

a) Using diagrams to support your points, explain the operating principles of a siphon.
(5 marks)

b) Explain how flow is achieved from a system that requires a siphon. (5 marks)

c) An open V shaped channel has sides inclined at 60^o to the vertical. The slope of the channel is 1 in 50 and the depth of flow at the centre is 0.5m. Assuming a Chezy constant of 50 $m^{1/2}/s$, calculate the volume rate of flow. (10 marks)

Examiner Feedback

This question was the least well answered question.

Most candidates recognised that the purpose of a siphon is to transfer a fluid from one reservoir to another but the methods needed to overcome a vacuum in order to achieve flow were not well understood.

When completing the calculation in part c), the majority of candidates used an incorrect equation. Despite the fact that there are only two to choose from, candidates usually chose the equation which relates to a horizontal V channel and not an inclined one as stated in the question. The correct answer to this question was: $1.41 \times 10^{-4} m^3/s$

Date issued: July 2020