PHYSICS

Unit 1 – Written examination

TSSM™
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2019 Trial Examination

SOLUTIONS

SECTION A: Multiple-choice questions (1 mark each)

Question 1

Answer: **B**

Explanation:

The zeroth law of thermodynamics states when two bodies are in thermal equilibrium with a third body, then they will be in thermal equilibrium with themselves.

Question 2

Answer: **C**

Explanation:

$Q = U + W$ so if Q, the heat gained by the system is equal to W, the work done by the system, then there will be no change in U, the internal energy.

Question 3

Answer: **C**

Explanation:

$Q = mc\Delta T$

$(mc\Delta T)_{metal} = (mc\Delta T)_{water}$

$0.2 \times c \times (41.76 - 31.4) = 0.06 \times 4200 \times (31.4 - 24)$

$c = 900 \text{ J kg}^{-1} \text{°C}^{-1}$

Question 4

Answer: **A**

Explanation:

Particles in a liquid are closer together and have less energy than in a gas.

Question 5

Answer: **B**

Explanation:

$(mL + mc\Delta T)_{ice} = (mc\Delta T)_{water}$

$0.05 \times 3.34 \times 10^5 + 0.05 \times 4200 \times (T - 0) = 0.1 \times 4200 \times (75 - T)$

$16700 + 210T = 31500 - 420T$

$T = 23.49 \text{ °C}$

Question 6

Answer: **B**

Explanation:

Convection is the movement of a fluid.

Question 7

Answer: **A**

Explanation:
The enhanced greenhouse gases in order of significance are water vapour, carbon dioxide, methane and nitrous oxide.

Question 8

Answer: **A**

Explanation:

$$Q = It$$

$$Q = 10 \times 10^{-3} \times 60 = 0.6 \text{ C}$$

$$the\ number\ of\ electrons = \frac{Q}{1.6 \times 10^{-19}} = \frac{0.6}{1.6 \times 10^{-19}} = 3.75 \times 10^{18}$$

Question 9

Answer: **C**

Explanation:

$$V_{out} = \frac{R_{out}}{R_{total}} \times V_{in}$$

$$5 = \frac{R_{out}}{R_{out} + 100} \times 9$$

$$R_{out} = 125 \; \Omega$$

Question 10

Answer: **D**

Explanation:

As $P = VI = \frac{V^2}{R} = I^2 R = \frac{E}{t}$, the only combination of units that are not correct is Volt÷Amp

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Question 11

Answer: **D**

Explanation: As the temperature decreases the resistance of a thermistor increases and a similar scenario is seen across an LDR, that is, as the light level decreases the resistance increases.

Question 12

Answer: **D**

Explanation: $R_{total} = R_1 + R_2 + R_3 = 10 + 15 + 25 = 50 \; \Omega$

Question 13

Answer: **A**

Explanation:

$$V_{total} = IR \qquad \text{OR} \qquad V = \frac{R}{R_{total}} \times V_{total}$$

$$9 = I \times 50 \qquad \qquad V = \frac{15}{10+15+25} \times 9$$

$$I_{total} = 0.18 \qquad \qquad V = 2.7 \text{ V}$$

Across the 15 Ω

$$V = 0.18 \times 15 = 2.7 \text{ V}$$

Question 14

Answer: **C**

Explanation:

The two 750 Ω resistors in parallel have an equivalent resistance of 375 Ω.
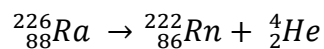The two 150 Ω resistors in parallel have an equivalent resistance of 75 Ω
These two parallel combinations in series with the 25 Ω resistor will have a combined resistance of 475 Ω

Question 15

Answer: **C**

Explanation:

$$^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$$

Question 16

Answer: **B**

Explanation:

The binding energy is the energy that needs to be provided in order to disassemble an atom.

Question 17

Answer: **B**

Explanation:

Repeated halving of the initial amount gives 1200 → 600 → 300 → 150 → 75. Therefore, there are 4 half-lives during this time. If each half-life has a time period of 12 minutes the total time is $12 \times 4 = 48$ minutes.

Or,

$$N_{final} = N_{initial} \left(\frac{1}{2}\right)^n$$
$$75 = 1200 \left(\frac{1}{2}\right)^n$$
$$\frac{75}{1200} = \left(\frac{1}{2}\right)^n = \frac{1}{16} = \frac{1}{(2)^4}$$

Hence, n = 4

Time = 12 x 4 = 48 minutes.

Question 18

Answer: **C**

Explanation:

Cosmic background radiation is thought to be the left over radiation from the Big Bang when protons and electrons formed.

Question 19

Answer: **B**

Explanation:

Baryons have 3 quarks and protons and neutrons are baryons hence $9 \times 3 = 27$ quarks. Electrons are leptons and as the atom is uncharged, and there are 4 protons, there are 4 electrons and hence 4 leptons.

Question 20

Answer: **C**

Explanation:

Fermions include quarks and leptons, therefore protons, neutrons and quarks are fermions. Photons do not fit in this group.

SECTION B: Short-answer questions

Question 1 (5 marks)

a. $\Delta U = Q - W$ where W is the work done by the system
$+8 = Q - 25$
$Q = +33$ J

Hence Annie is correct there has been 33 J of energy added to the system in order for there to be an increase in internal energy of 8 J.

3 marks

b. $\Delta U = Q - W$
$\Delta U = 15 + 21 = 36$ J

Total change in internal energy is therefore $\Delta U = 8 + 36 = 44$ J

2 marks

Question 2 (8 marks)
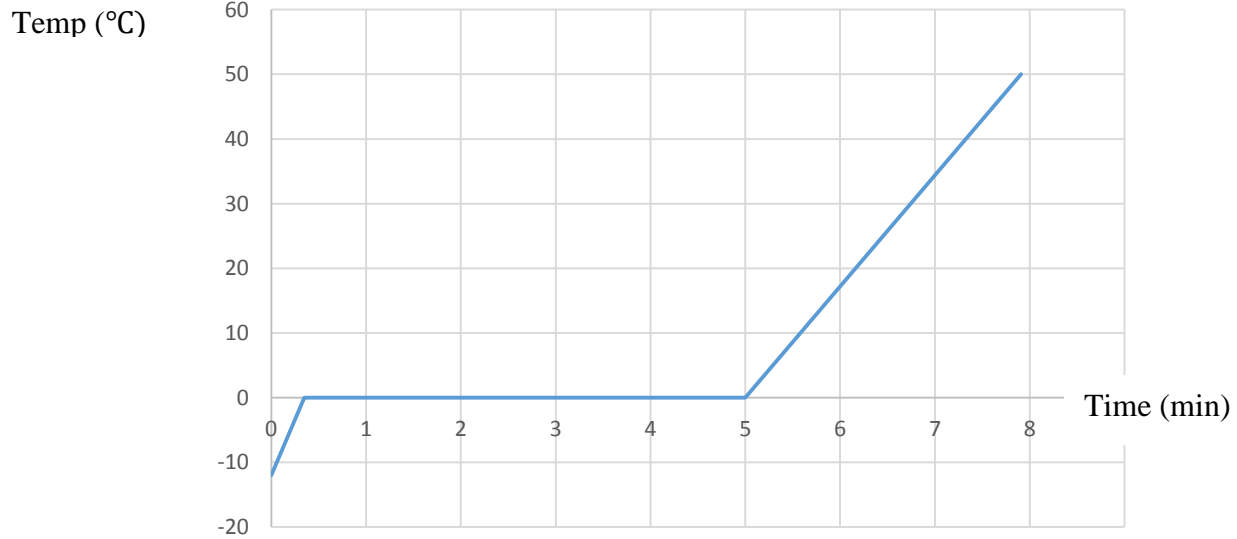
a. $Q = mc\Delta T + mL$
$Q = 0.25 \times 2100 \times 12 + 0.25 \times 3.34 \times 10^5 = 89800$ J

3 marks

b. $E = Pt$
$89800 = 300t$
$t = 299.33$ s
$t = 5$ minutes

2 marks

c.

Temp (°C)

$$t = \frac{E}{P}$$

Time to heat liquid water $= \dfrac{0.25 \times 4200 \times 50}{300} = 175 \text{ s}$

$t_{total} = 5 \times 60 + 175 = 475 \text{ s}$

3 marks

Question 3 (3 marks)

$(mc\Delta T + mL + mc\Delta T)_{ice} = (mc\Delta T)_{water}$

$m \times 2100 \times (0 - -15) + m \times 3.34 \times 10^5 + m \times 4200 \times (29 - 0) = 0.5 \times 4200(70 - 29)$

$31500m + 3.34 \times 10^5 m + 121800\, m = 86100$

$m = \dfrac{86100}{487300} = 0.17669$

$m = 0.18 \text{ kg}$

Question 4 (3 marks)

Heat provided to the saucepan from the stove top is via radiation. Heat is then conducted through the saucepan to the water. The water heats via convection. Heat is then conducted through the egg shell to cook the egg.

Question 5 (4 marks)

a. The greenhouse effect is a natural process that heats the Earth's surface. Radiation from the sun reaches the Earth's atmosphere, some is reflected and the rest is absorbed by the surface. Infrared radiation is then reemitted from the surface of the Earth and trapped by greenhouse gases creating a warmer environment.

2 marks

b. Scientists are worried about the enhanced greenhouse effect with gases such as carbon dioxide, methane and additional water vapour being added to the natural greenhouse gases. This causes additional infrared radiation to be trapped resulting in an increase in temperatures within the Earth's atmosphere.

2 marks

Question 6 (7 marks)

a. $V_{total} = 240$ therefore each globe will have 24 V

$P = VI = 24 \times 0.15 = 3.6$ W

3 marks

b. $Q = It = 0.15 \times 2 \times 60 \times 60 = 1080$ C

2 marks

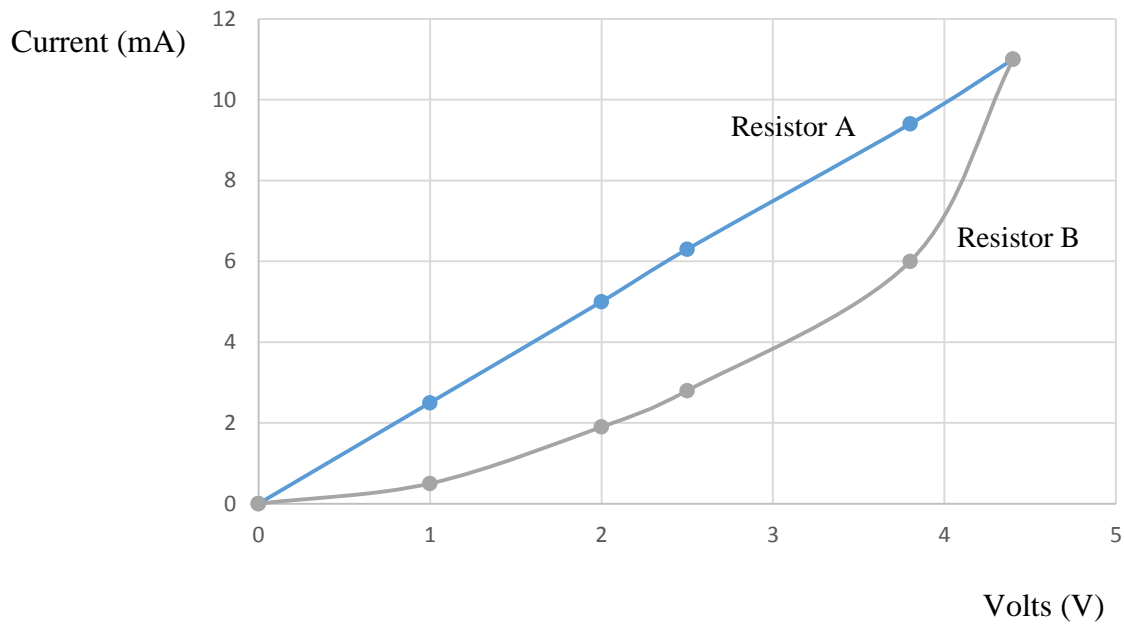**c.** $E = QV = 1080 \times 24 = 25920$ J
Or
$E = Pt = 3.6 \times 2 \times 60 \times 60 = 25920$ J

2 marks

Question 7 (9 marks)

a.

3 marks

b. Resistor A is Ohmic as it has a linear relationship between voltage and current.

2 marks

c. $R = \frac{V}{I} = \frac{4.4}{11\times10^{-3}} = 400 \ \Omega$

2 marks

d. 3.5 V across the non-ohmic resistor has a current of 5 mA.
Therefore $P = VI = 3.5 \times 5 = 17.5$ mW (Accept a range of 17-18 mW)

2 marks

Question 8 (8 marks)

a. Bottom series line has a resistance of $2.5 + (\frac{1}{15} + \frac{1}{15})^{-1} = 10 \ \Omega$

This line is then in parallel with the second line hence $(\frac{1}{5+20} + \frac{1}{10})^{-1} = 7.14 \ \Omega$

Total effective resistance therefore is equivalent to $7.14 + 10 = 17.14 \ \Omega$

3 marks

b. $V = IR$
$10 = I \times 17.14$
$I = 0.58$ A

2 marks

c. $V_{10} = 0.58 \times 10 = 5.8$ V

Voltage across parallel components $= 10 - 5.8 = 4.2$ V

Current in bottom $4.2 = I \times 10$
$I = 0.42$ A

$V_{2.5} = 0.42 \times 2.5 = 1.05$ V

3 marks

Question 9 (6 marks)

a. $30°C = 8$ KΩ

1 mark

b. $V_{out} = \frac{R_{out}}{R_{total}} \times V_{in}$

$8 = \frac{R_{out}}{R_{out} + 8000} \times 12$

$0.667(R_{out} + 8000) = R_{out}$

$R_{out} = 16$ kΩ

2 marks

c. The resistance across the thermistor will increase at a lower temperature. In order to keep the voltage across the variable resistor the same at 8 V, the variable resistor must also increase.

3 marks

Question 10 (7 marks)

a. For an electron to be ejected from the nucleus of an atom, a neutron must convert into a proton and an electron. The electron is then ejected from the nucleus while the proton remains.

2 marks

b. $^{131}_{53}I \rightarrow {}^{131}_{54}Xe + {}^{0}_{-1}e + \tilde{v}$
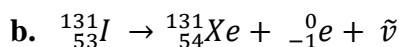
2 marks

c. Half-life is the time for half the sample to decay hence from the graph 8 hours.

<div align="right">1 mark</div>

d. In 32 hours, there are 4 half-lives therefore $0.75 \times 2^4 = 12$
Activity must be 12 MBq.

<div align="right">2 marks</div>

Question 11 (4 marks)

a. The Doppler Effect is either the perceived lengthening in the wavelength from a source that is moving away from an observer or the perceived shortening in wavelength of a source moving towards an observer. With light, the light from a source moving away is shifted towards the red end of the spectrum while light from a source moving towards the observer is shifted toward the blue end.

<div align="right">2 marks</div>

b. The Big Bang theory suggests the universe started as a small singularity that has then inflated over the past 13.8 billion years. The Doppler Effect supports this theory as scientists now view the vast majority of stars within the universe to be red shifted and thus moving away from us.

<div align="right">2 marks</div>

Question 12 (6 marks)

a. Fundamental particles are small subatomic particles that are the building blocks of the universe. A fundamental particle is a particle which cannot be broken down further. For protons and neutrons, they combine together. Electrons are their own fundamental particle.

<div align="right">2 marks</div>

b. Particles that make up matter such as protons etc are called fermions
Particles that carry force which help keep these particles together are called bosons.

<div align="right">2 marks</div>

c. i. Neutron is made up of 2 Down quarks and 1 Up quark. $\frac{-1}{3} + \frac{-1}{3} + \frac{2}{3} = 0$ charge

    ii. Proton is made of 2 Up and 1 Down quark. $\frac{2}{3} + \frac{2}{3} + \frac{-1}{3} = +1$ charge

<div align="right">$1 + 1 = 2$ marks</div>