Physics: Examiners comments for consideration in admissions decisions

Recommendations for during the decision making process:

1. Reviewing the actual section 2 scripts of the candidates will provide useful information to add to the decision process – in particular when considering the mathematical fluency and accuracy in combination with the ability to explain and understand the underlying physical principles (see question P1 comments)

The last three years have clearly shown that candidates do not use their time evenly, with the first question that they attempt dominating the mark profile. When considering the moderation spreadsheet alone, it is not apparent which was the first question; furthermore each question has a different mean, making these marks not as useful as they could be.

2. It would be my recommendation to Directors of Studies, therefore, that marks for each question are scaled to match the means, and the total score across both questions is then considered. (e.g. P1+C1, P1+C2). Given the means this year, this wouldn't need to be a laborious process. For example, if we wished the mean for all subjects to be 10 then a simple scaling (calculated in the spreadsheet) using something like $10 + \left(\frac{N \le score}{N_{total}} - 0.5\right) * 20$ [which scales the top mark to be 20 ($\frac{N \le 20}{N_{total}} = 1$)] would enable marks to be added and the total across both questions considered.

Question P1

This question was designed not only to test students' mathematical ability, fluency and accuracy but also to test their understanding of physical concepts and their ability to explain them. This was a useful exercise as it was clear that many students (often overseas students) were able to reliably and efficiently perform calculations, but had no physical understanding of what this meant, and were therefore unable to describe or draw the graphs in part (a) and (e). It was clear from this question that students lacked practice in explaining physical systems in a concise manner with simple short statements. They often wrote complicated, confused and contradictory statements.

From the last three years of marking the admissions tests, it is clear that the first question on the paper is attempted by the greatest number of students and, generally, students were able to make good progress on this question. Our decisions about marks were therefore quite strict (to discriminate between candidates who had a clear and accurate understanding of the physics and were reliable and critical with their mathematics) and taken within the whole context of all of the scripts.

Most students progressed all the way through this question – possibly to the detriment of later questions.

Question P2

The question on simple circuits was designed to be accessible to most A level students who have studied electric circuits. Only two equations are required; $V = IR$ and $P = \frac{V^2}{R}$. The parts of this question were separate, requiring simple calculations or sometimes the graphs could be sketched without numerical calculations. Even within the sections the parts of the question could be approached without having correctly obtained the earlier answers in the section.

Somewhat evident was the lack of practice in doing simple calculations without forgetting the component they were meant to be considering halfway through. So a student would find some set of potentials across the "other" resistor in the circuit. This well-meaning effort on their part could be very frustrating when you could see that they could have answered the question correctly.

Generally, they found the electricity question hard (although it is certainly a very straightforward question of its type) but they tend not to have a feel for the behaviour of currents and potentials in simple circuits. They can do calculations, but may get confused along the way by having to consider more than one step at a time in their head. They could set the steps down, but they are not used to multistep calculations without a support step in the middle. These were like physics problems, without the level of technical difficulty, but with the requirement to hold on to more than one thought at a time.

There were a small number of students from overseas who appeared to know almost no electricity. Other than that, students who attempted the question could generally make progress, getting sections correct or incorrect independently, even though one might think that they had the principle at one moment whilst they then appeared to lose their way in another section.

When calculating a table of results, it was sometimes evident that they were using a calculator, but were not systematic about tabulating the intermediate results and seeing that they followed a pattern.

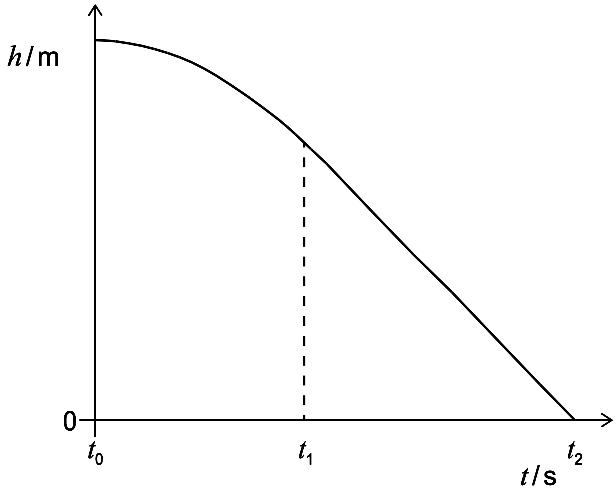
It was quite clear that they did not have enough time to complete the question, particularly if they chose to do the two physics questions and naturally had spent too long on the first one.

The mark scheme had some amendments made as a result of seeing a sample of student scripts, but some of these adjusted details for awarding marks have not been included here.

Physics

Question P1

A ball, of mass m is dropped and falls vertically from a high window. The graph illustrates the height of the ball above the ground, h, as a function of time t since the ball was dropped.



a) In words, relate the speed of the ball to the gradient of the graph at time t_0 and in the two time intervals t_0 to t_1, t_1 and t_2.

[6 marks]

Answer: *Students who performed poorly on this part of the question usually did so because they didn't actually answer the question asked. A few talked about forces on the ball correctly but without relating the speed of the ball to the gradient of the graph. Some students spent much longer than necessary writing correct physical statements but those statements were not relevant to the question. Where incorrect physics was cited, marks were not given (e.g. accelerating at an increasing rate). It was clear from this question that students lacked practice in explaining physical systems in a concise manner with simple short statements. They often wrote complicated, confused and contradictory statements.*

At t_0 : the speed of the ball is zero at the start [1 mark]

therefore the gradient of the line is zero (flat) [1 mark]

Many students neglected to answer this part of the question.

t_0 to t_1: the ball is accelerating [1 mark]

…………therefore the gradient is always changing [1 mark]

(or the line is curved, or the gradient is not constant)

The gradient of h-t tells us about the velocity and the gradient is always increasing which means the velocity is always increasing therefore the ball is accelerating due to a resultant force.

Students who said (or inferred) that acceleration was constant (some said at g) between t_0 and t_1 were not given the first mark.

t_1 to t_2: the ball has reached terminal (or maximum) speed [1 mark]

therefore the gradient is constant because there is no resultant force on the ball. *(or the line is straight will be accepted)* [1 mark]

This part was usually done well.

b) The drag force on the ball caused by air resistance is given by F_d.

Using Newton's second law, find an equation for the acceleration a of the ball in terms of F_d, m, and g where g is the gravitational field strength.

[2 marks]

Answer: …Using Newton's Second Law

$mg - F_d = ma$ [1 mark]

$a = g - F_d/m$ [1 mark]

(we will accept either up or down as defined as positive)……………………….

full 2 marks if expression for a is correct even without the first expression………………

A number of students did not give the final line of this answer, leaving their response as "$ma =$".

c) If the drag force on the ball is given by $F_d = \frac{1}{4}\pi r^2 \rho v^2$, where ρ is the density of the air, r is the radius of the ball, and v is the instantaneous speed of the ball.

Find an expression for the terminal speed of the ball v_t, in terms of m, g, r and ρ.

[3 marks]

Answer: …………………………………………………………………………………………..….

Terminal velocity implies $a = 0$ therefore $F_d = mg$ [1 mark]

$$\frac{\pi}{4} r^2 \rho v_t^2 = mg$$

[1 mark]

(or for any sensible rearrangement such as $v_t^2 = \frac{4mg}{\pi r^2 \rho}$)

$$v_t = \frac{2}{r}\sqrt{\frac{mg}{\pi\rho}}$$

[1 mark]

(all marks will be given for a correct answer whether these three steps are taken or not. It must be clear however how the answer has been arrived at.

For example, only 1 mark will be given if the final line is stated without any explanation of a=0

two out of three marks if the answer is given as v not v_t.)

Generally well answered: mistakes involved not transposing the drag forces correctly from the question and failing to rearrange correctly.

d) Calculate the value of the terminal speed of the ball given that it has a mass $m = 25\,\text{g}$, a radius $r = 25\,\text{cm}$, and that the density of the air $\rho = 1.2\,\text{kg m}^{-3}$.

(gravitational field strength = $9.8\,\text{N kg}^{-1}$)

[2 marks]

Answer: $\ldots v_t = \frac{2}{r}\sqrt{\frac{mg}{\pi\rho}} = \frac{2}{25\times10^{-2}}\sqrt{\frac{25\times9.8\times10^{-3}}{3.14\times1.2}}$ [1 mark]

$v_t = 2.0(4)\ \text{m s}^{-1}$ [answers that had used $g = 10\ ms^{-2}$ → 2.06 and no second mark][1 mark]

One mark for correctly converting units from cm *and* g, one *mark for the correct answer.*

Correct unit conversion mark is equivalent to an error carried forward mark for an incorrect expression from (c). i.e. if an incorrect expression is calculated and carried forward students can still achieve 1 mark for correctly converting units. If excessive sig figs were given or units were missing 1 mark was deducted (this rule was only applied once for the whole of P1).

The main source of error in this question was incorrect unit conversions and students failing to take the square root on their calculator.

e) Sketch a graph of the ball's speed against time, labelling the terminal speed of the ball.

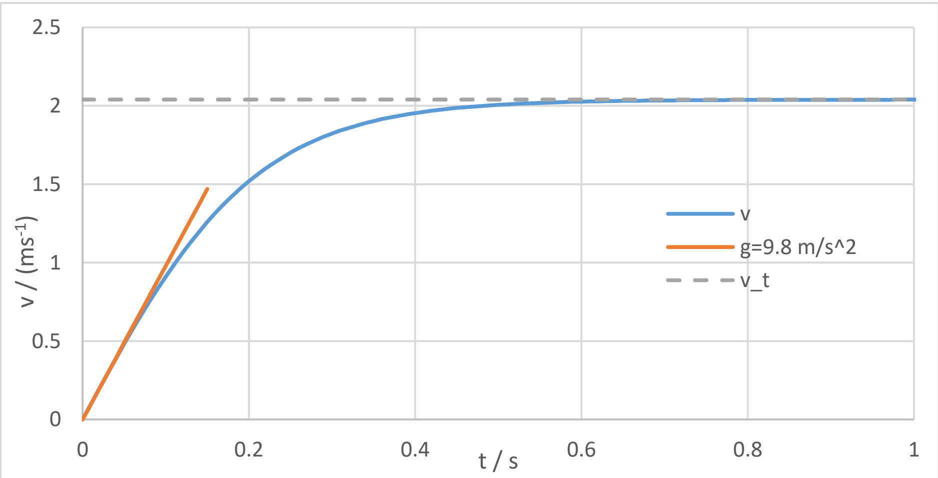
In words, relate the acceleration of the ball to the gradient of your speed-time graph.

[4 marks]

Answer:

Correct line shape (graph may be inverted – either sign allowed), which means…

- reaching horizontal line (gradient = 0) and stating acceleration therefore is zero. [1 mark]



- v_t labelled symbolically or numerically… [1 mark]
- Between zero and v_t the line is curved with the right sign of curvature as shown in sketch above. [1 mark]
- Initial gradient at $t_0 = g = 9.8\ \text{ms}^{-1}$ (just saying "greatest" insufficient) [1 mark]

Most students understood the physics of this system and were able to sketch this graph correctly. However, answers were often inconsistent with the description given for part (a). Marks were lost for ***not*** *labelling the terminal velocity as asked (benefit was given here for non-conventional labelling) and marks were lost for indicating that the acceleration was constant for an extended period of time (showing a straight line with constant +ve gradient or curvature for only a small portion of the time before reaching v_t). .*

f) The velocity of the ball varies with height according to the equation

$$\left(\frac{v}{v_t}\right)^2 = \left(1 - 10^{\frac{-cy}{m}}\right)$$

Where $m = 25\,\text{g}$, $c = 0.051\ \text{kg m}^{-1}$ and y is the distance the ball has fallen from the window; $y = 0$ at the start of the fall.

Calculate the distance that the ball has fallen when its speed is equal to 99% of its terminal speed.

[3 marks]

Answer: ……………………………………………………………………………………………**....**

$(0.99)^2 = \left(1 - 10^{\frac{-cy}{m}}\right)$ [correctly use the 99%] [1 mark]

$\frac{-cy}{m} = \log\,(1\text{-}0.99^2)$ [re-arrange correctly using logs] [1 mark]

y = 0.83(3) m (or 83 cm) [get correct answer] [1 mark]

…

(If students use $\ln$ rather than $\log$ they get 2 marks out of 3, as long as everything else is correct) This gives $y = 1.9(2)m$.

Common mistakes in this question were incorrect manipulation of $\log s$, incorrect unit conversions, rounding too soon, and using numbers too early (i.e. calculating 99% of their value from e rather than just squaring 0.99). Also, incorrect manipulation of algebra before taking logs. Benefit was given if the correct answer was stated as -0.83m even though y should be a positive number.

Question P2

Assume throughout this question that the cells and batteries have no internal resistance.

A light-emitting diode (LED) has the I–V characteristic graph shown in Fig. 2a:

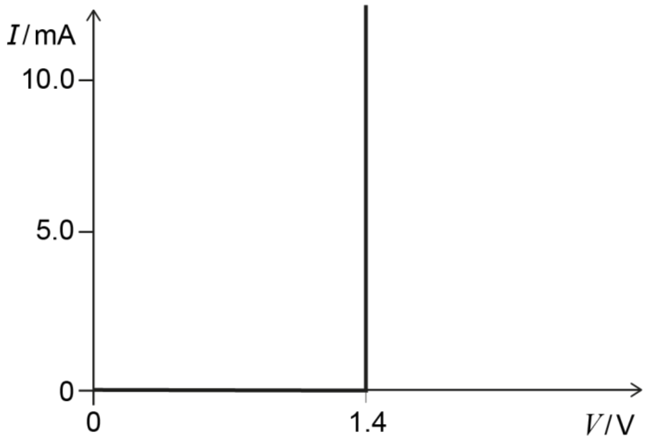


Figure 2a

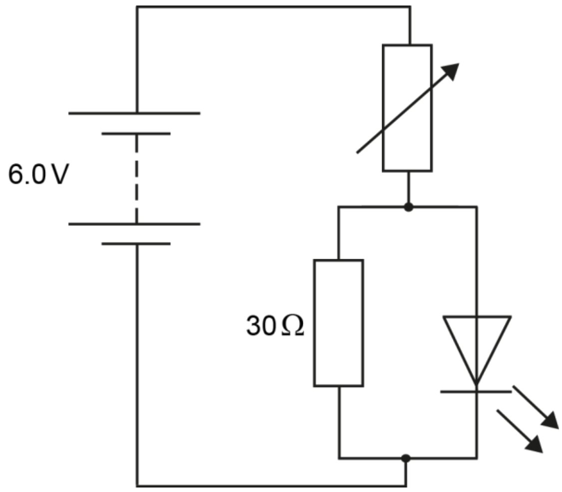


Figure 2b

If the potential difference across the LED is less than 1.4 V, no current passes through it. When a current does pass through the LED, the potential difference across it is always 1.4 V.

This LED is connected into the circuit shown in Fig. 2b, and the variable resistor is adjusted until there is a current of 8.0 mA through the LED.

a) **(i)** What is the potential difference across the 30 Ω resistor? **[1 mark]**

Answer: ………1.4 V ……………………………………………………………………..…..

Components in parallel have the same potential across them. So 1.4 V

…………………………………………………………………………………………………

(ii) What is the current through the 30 Ω resistor? **[1 mark]**

Answer: ………$I = \frac{1.4}{30}$ = 0.047 A (or 47 mA)……………..…

two significant figures are given, and so the answer is expected to be the same. Sometimes 3 or 4 figures were given, and sometimes only 1, but this was not the moment to penalise such infelicities.

$I = \frac{1.4}{30} = 0.047\ A = 47\ mA$ *ecf was allowed if they used 4.6 V to give 153 mA*

b) (i) What is the current through the variable resistor? **[1 mark]**

Answer: ……(47+8) mA = 55 mA……(= 0.0547 A) ……..……………………………………..…

The two currents in parallel were added to give 47 + 8 = 55 mA. All sorts of rounding errors were catered for here. Ecf was allowed from earlier (153 + 8 = 161 mA)

Sometimes there was a very poor approach to considering the sig figs here.

(ii) What is the potential difference across the variable resistor? **[1 mark]**

Answer: ……6.0 - 1.4 = 4.6 V…………………………………………………………………..…

6.0 – 1.4 = 4.6 V with no variations allowed here. Some students felt that this should be some combination of the various potentials available.

(iii) What is the resistance of the variable resistor? **[1 mark]**

Answer: ……$R = \frac{4.6}{55\times10^{-3}} = 84\ \Omega$…………(= 84.14 Ω) ……………..…

This is 84.(1) Ω with a noticeable range of variations with the earlier rounding of the currents. All of these were allowed. Some students calculated a resistance for the LED, which though an artificial construct (175 Ω) could, in a convoluted way, be used along with the current and 6 V cell to obtain R.

c) The following circuit is constructed with a battery of emf 6.0 V, two fixed resistors and one variable resistor as shown in Fig. 2c.

The calculation in part (i) below is designed to get students to see the process of the potential divider with a variable resistor in a parallel arrangement with a simple value. In sketching the subsequent graph, the students' reasoning powers were being tested by considering the effect of R_{var} without necessarily doing any further calculations. When $R_{var} = 0$, R_2 is shorted and no current will pass through it, so that the full potential of 6 V is across R_1. Then as R_{var} is increased, a larger share of the potential is across its parallel arrangement and a smaller share of the potential across the voltmeter. A potential divider circuit in a different context. No mention is made of current in this part and students were fairly successful here. Sometimes the graphs went down to zero, or were entirely linear, but the decreasing trend was generally realised.

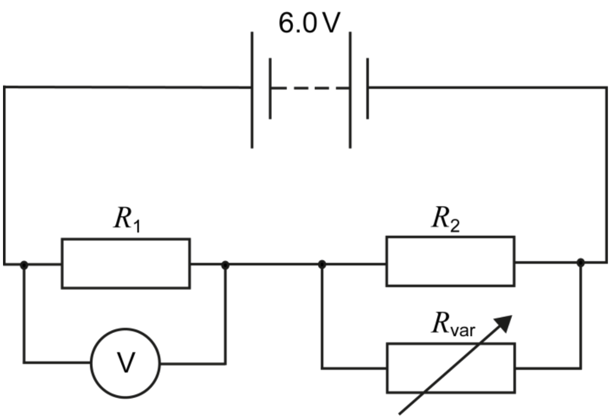


Figure 2c

$R_1 = R_2 = 20\,\Omega$, and R_{var} can be varied between 0 and 80 Ω.

(i) When R_{var} is set to 20 Ω, what is the voltage shown on the voltmeter?

[1 mark]

Answer: ……… $V = \frac{20\ \Omega}{(20+10)\ \Omega} \times 6.0 = 4.0$ V …………

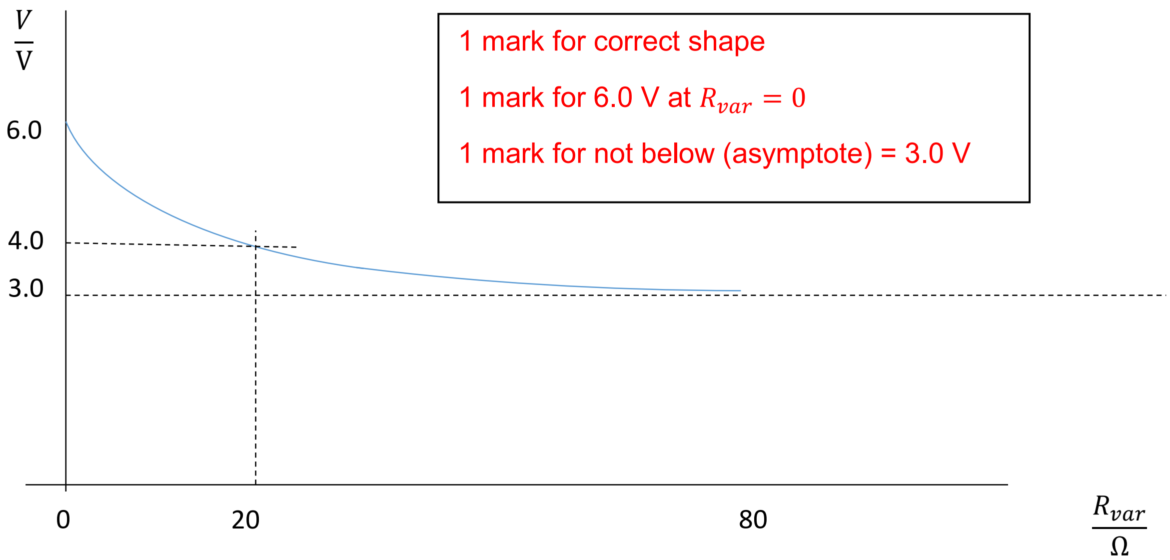
or $I = \frac{6.0}{(20+10)\Omega} = 0.2$ A So $V = 0.2 \times 20\ \Omega = 4.0$ V……..

……

(ii) Sketch a graph of the voltage shown on the voltmeter against R_{var} for values of R_{var} between 0 and 80 Ω. Plot your result from part **(i)** on your graph.

[3 marks]

Answer:



1 mark for correct shape

1 mark for 6.0 V at $R_{var} = 0$

1 mark for not below (asymptote) = 3.0 V

(iii) Calculate the potential difference across the variable resistor, and the power dissipated in the variable resistor, for $R_{\text{var}} = 0.0\,\Omega$, $5.0\,\Omega$, $20\,\Omega$, $50\,\Omega$ and $80\,\Omega$.

[5 marks]

Answer:
[students are not required to write these formulae down to get the marks – they can calculate the values anyway they like]

$$V_0 = V_i\left(\frac{R_{var}}{20 + 2R_{var}}\right)$$

$$P = \frac{V_0^2}{R_{var}} = \frac{V_i^2 R_{var}}{(20 + 2R_{var})^2}$$

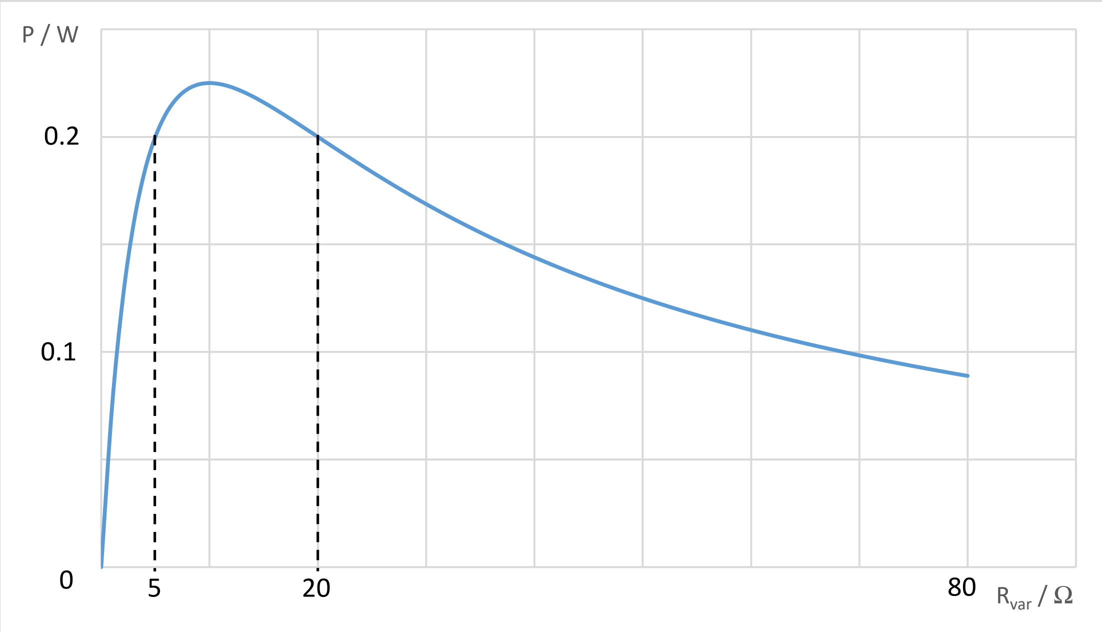
R_{var}	V/V	Power / W	
0	0	0	[1 mark]
5.0	6 x 5 / 30 = 1	1 / 5= 0.2	[1 mark]
20	6 x 20 / 60 = 2	4 / 20 = 0.2	[1 mark]
50	6 x 50 / 120 = 5/2	25/ (4 x 50) = 1/8 = 0.125	[1 mark]
80	6 x 80 / 180 = 8/3	64/ (9 x 80) = 8/90 = 0.09	[1 mark]

The power dissipated in the variable resistor was an exercise in being systematic. It might be argued that a table of five results for 5 marks was expecting an all or nothing set of marks. However, this was not the case. Students would get some results but not all. They would sometimes lose track of which resistor they were considering, writing down the potential across the other one, without momentarily checking that this made sense.
The initial example of $R_{var} = 0\ \Omega$ means that there will be no potential across it and hence no power loss in it. Of course a direct application of V^2/R_{var} will lead to 0/0 but that is taking a formula and not the physics of the situation. Here a moment's thought about I^2R with a finite current I through $R_{var} = 0$ would solve the issue. Again, using $R_{var} = 20\ \Omega$ means that there is 2 V across R_{var} as a simple potential divider (with 20 Ω and 20 Ω in parallel), and then $\frac{V^2}{R_{var}} = 0.2\ W$. Having a systematic approach is one of the skills being tested, and those who avoided scribbling a lot of equations and numbers around the page were obviously more successful. At this stage clearly many candidates were very short of time. The graph following could be obtained by sketching for the table, or quite often just from some thinking about the circuit. When $R_{var} = 0$ no power is dissipated, and when R_{var} is large, little current flows through it and again little power is dissipated. In between power is dissipated, so the graph has a peak in it. It was pleasing to see students obtaining this without necessarily having produced a table of results. Students will have come across the maximum power from a cell and the fact that a maximum is obtained here may not be a great surprise, although to connect the circumstance is perhaps hindsight here.

(iv) Using your results from **(iii)**, sketch a labelled graph of the power dissipated in the variable resistor against R_{var} from 0 to 80 Ω.

[3 marks]

Answer:



[1 mark] for steep incline

[1 mark] to a maximum between the values of 5 ohms and 20 ohms.

[1 mark] for shallow decline from maximum to correct value at 80 ohms. This should indicate a tending to an asymptote of P=0 W not an asymptote of 0.09 W. i.e. if R_{var} could tend to infinity the power would tend to zero not to the value calculated for 80 ohms.

[-1 mark if students have not labelled the graph with numbers and/or units]

[1 mark should be given if maximum power is calculated at 10 ohms & 0.225 W but something else is left out – students are not explicitly required to calculate this]

Not required:

Differentiating the expression for P, to set $\frac{\mathrm{d}P}{\mathrm{d}R} = 0$

$$P = \frac{V_{var}^2}{R_{var}} = \frac{V_i^2 R_{var}}{(20 + 2R_{var})^2}$$

The max power in R_{var} is for $R_{var} = 10\ \Omega$ and is $P_{max} = \frac{9}{40} = 0.225\ \mathrm{W}$

d) A potentiometer is a three-terminal device often used as a variable resistor by only using two of the three terminals (one end of the resistive track and the sliding contact). An example is shown schematically in Fig. 2d. In a logarithmic potentiometer the resistance varies with the angle of rotation, θ.

The graph in Fig. 2e shows how the logarithm of the resistance R_{AB} varies linearly with angle θ.

θ can vary between 0° and 270°.

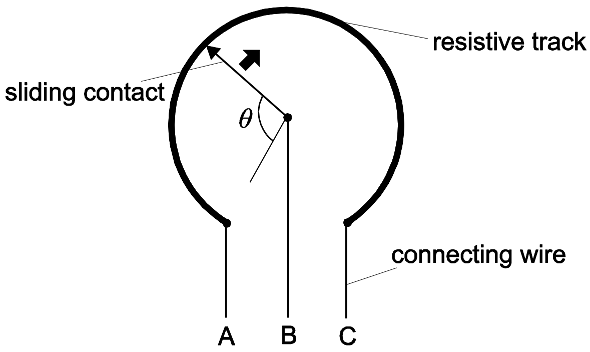


Figure 2d

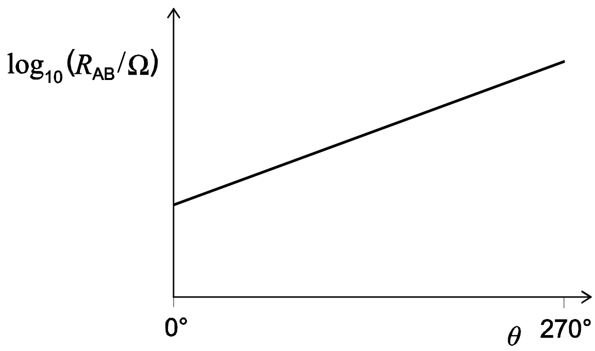


Figure 2e

If the resistance when $\theta = 0°$ is $R_{AB} = 1.00\,\text{k}\Omega$, and when $\theta = 270°$ is $R_{AB} = 2.00\,\text{M}\Omega$, what is the value of R_{AB} when $\theta = 110°$?

[3 marks]

Answer:

$$\log R_{AB} = k\theta + c$$

$$\log R_{AB} = \frac{(\log 2\times 10^6 - \log 10^3)}{270^o}\theta + \log 10^3$$

$$= \frac{\log 2 + 6 - 3}{270^o}\theta + 3 \quad = \quad \frac{\log 2 + 3}{270^o} \times 110^o + 3$$

$$= \frac{11}{27}\log 2 + \frac{38}{9} \quad = \quad 4.345$$

$$R_{AB} = 22.1(2)\ \text{k}\Omega$$

OR Result and some reasoning [3 marks]

OR

$\log(10^3) = c$, hence $c = 3$ [1 mark]

$k = \frac{\log R_{AB}(270) - \log R_{AB}(0)}{270-0} = \frac{1}{270}\log\left(\frac{R_{AB}(270)}{R_{AB}(0)}\right) = \frac{1}{270}\log\left(\frac{2\times10^6}{10^3}\right) = 0.0122(3)$ [1 mark]

mark for finding each constant if constants are incorrect but students identify correct straight line expression ($\log R_{AB} = k\theta + c$) then 1 mark out of 2 given.

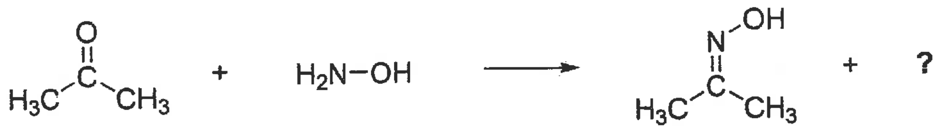
Hence at $\theta = 110°$, $R_{AB} = 22 \times 10^3\ \Omega = 22.1(2)\ \text{k}\Omega$ [1 mark]

The last section was an interpolation of a linear graph, with a log scale. Fairly successful for candidates who got this far (if they did not entirely ignore the log scale), although it was decidedly thin on the ground for the 900 plus candidates who attempted this P2 question. Time was the key factor.

Chemistry

Question C1

a) Ketones react with hydroxylamine, NH_2OH, to give oximes. An example of such a reaction involving the ketone propanone is shown below:



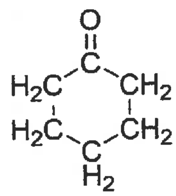
propanone (a ketone)   hydroxylamine   an oxime

(i) In addition to the oxime, this reaction produces a second product. Suggest what this molecule might be.

[1 mark]

Answer: H_2O or water [1]

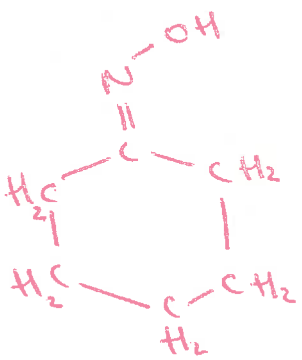
(ii) Draw the structure of the oxime that you would expect to be formed from the reaction of the ketone cyclohexanone with hydroxylamine.



cyclohexanone

[2 marks]

Answer:

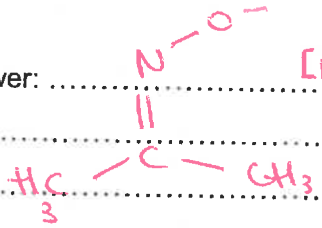


oxime = [1]
cycle = [1]

(iii) Oximes are weakly acidic. For the oxime below, explain which hydrogen atom will be the most acidic and draw the structure of the resulting anion **X⁻**.

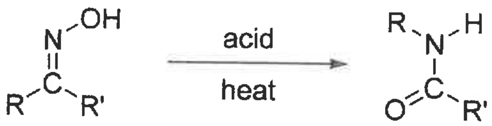
oxime

[3 marks]

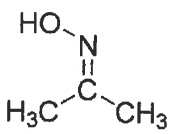
Answer:  [1] O is electronegative [1]

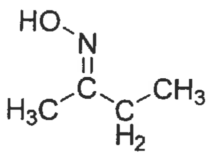
Stabilises negative charge [1]

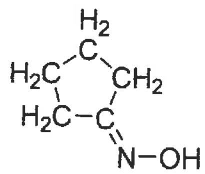
b) Under acidic conditions, oximes undergo the following rearrangement reaction (note carefully that there are two different groups R and R').



Give the analogous structures into which each of the following oximes rearrange under the same conditions.

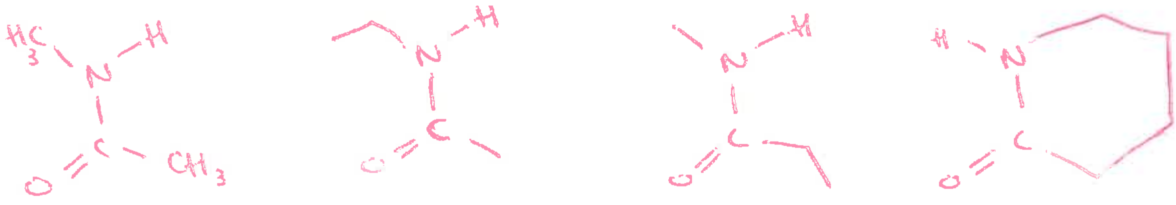






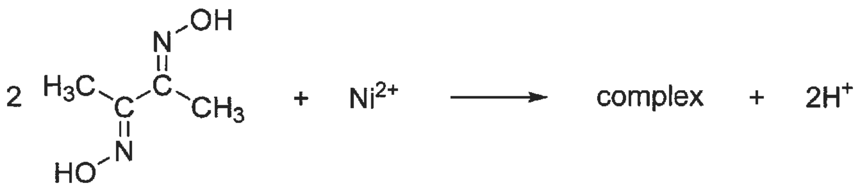
[4 marks]

Answer:



[1] [1] [1] [1]

c) Dimethylglyoxime reacts with Ni^{2+} ions in aqueous solution under mildly basic conditions to give a complex which is an insoluble red precipitate. The reaction involves two molecules of dimethylglyoxime and also results in the production of two H^+ ions.



dimethylglyoxime

Assuming that the above equation is balanced, determine the **molecular formula** of the complex and its relative molecular mass; a structural formula is **not** required.

(Relative atomic mass data is given in the Periodic Table on page 14.)

[4 marks]

Answer: $Ni((C_4O_2N_2H_7)_2$ $= NiC_8O_4N_4H_{14}$ [2]

Mass = 288.922 [2]

[Turn over

d) The reaction between dimethylglyoxime and Ni^{2+} ions can be used to determine the nickel content of alloys by weighing the amount of the red precipitate produced from a known mass of a sample of an alloy.

A sample of mass 1.50 g of an alloy was dissolved in dilute acid and an excess of dimethylglyoxime was then added to the resulting solution. The pH was then adjusted to make the solution mildly alkaline, and this resulted in the formation of a red precipitate. The precipitate was carefully filtered off, dried and then weighed. The mass of the dry precipitate was 0.368 g.

Determine the nickel content of the alloy, expressed as a percentage by mass.

[4 marks]

Answer: $\frac{0.368}{288.922} = 1.2737 \times 10^{-3}$ mol [1]

Amount of Ni = 1.2737×10^{-3} mol [1]

Mass of Ni = 0.07475 g [1]

% Mass of Ni = 4.98356 % [1]

e) Other metal ions, such as Pd^{2+} or Pt^{2+}, also react with dimethylglyoxime to give insoluble precipitates. What effect would the presence of palladium in the alloy have on the value of the nickel content determined using the method in part **d)**?

[2 marks]

Answer: Pd / Pt will precipitate → increase in mass. [1]

Make the Ni (%) look too high = wrong answer [1]

for Ni value.

Question C2

a) Write a balanced chemical equation for the reaction between $CO_2(g)$ and $OH^-(aq)$, giving $CO_3^{2-}(aq)$ as one of the products.

[1 mark]

Answer: $CO_2\ (g) + 2OH^-\ (aq) \rightarrow CO_3^{2-}(aq) + H_2O\ (l)$ [1]

Accept: no state symbols

$CO_2 + OH^- \rightarrow CO_3^{2-} + H^+$

but this is incorrect for (b)(ii) and (b)(iii)

b) An organic molecule is known to contain C, H and O only. A sample of mass 0.100 g is carefully burnt in the presence of excess oxygen. The resulting gases are passed over a desiccant (drying agent), and it is observed that the mass of the desiccant increases by 0.0931 g.

After passing through the desiccant the gases are bubbled through 25.0 cm^3 of a solution of 1.00 mol dm^{-3} NaOH. The solution is then titrated against 1.00 mol dm^{-3} HCl, and the end point is found to be when 14.7 cm^3 of the acid has been added.

(i) Calculate the amount in moles of H_2O produced by the combustion.

[2 marks]

Answer: $m_{H_2O} = 0.0931\,g$ [1]

$n_{H_2O} = \frac{0.0931\,g}{16.00 + 2 \times 1.008} = 5.167628774 \times 10^{-3}$ mol

$\approx 5.17 \times 10^{-3}$ mol [1]

(ii) Calculate the amount in moles of CO_2 absorbed by the NaOH solution.

[4 marks]

Answer: $n_{HCl} = 14.7 \times 10^{-3}\,dm^3 \times 1.00\ mol\,dm^{-3}$

$= 14.7 \times 10^{-3}$ mol $\equiv 0.0147$ mol [1]

$n_{OH^-\ titrated} = n_{HCl} = 14.7 \times 10^{-3}$ mol [1]

$n_{OH^-\ reacted\ with\ CO_2} = (25.0 \times 10^{-3}\,dm^3 \times 1.00\ mol\,dm^{-3})$

$- 14.7 \times 10^{-3}$ mol [1]

$= 10.3 \times 10^{-3}$ mol $\equiv 0.0103$ mol

$2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$

2 : 1

$n_{CO_2} = 10.3 \times 10^{-3}$ mol $\times \frac{1}{2} = 5.15 \times 10^{-3}$ mol

$= 0.00515$ mol [1]

If 1:1 ratio in a), accept e.c.f: 10.3×10^{-3} mol [1]

[Turn over

(iii) Hence determine the empirical formula of the organic molecule.

[6 marks]

Answer: $n_C = n_{CO_2} = 5.15 \times 10^{-3}$ mol [1]

$n_H = 2 \times n_{H_2O} = 2 \times 5.1676 \times 10^{-3}$ mol $= 10.335 \times 10^{-3}$ mol [1]

Mass of O in sample:

$0.100\,g - (5.15 \times 10^{-3}\,mol \times 12.00\,g\,mol^{-1})$
$- (10.335 \times 10^{-3}\,mol \times 1.008\,g\,mol^{-1}) = 0.02778\,g$ [1]

$\therefore n_O = \frac{0.02778\,g}{16.00\,g\,mol^{-1}} = 1.7364 \times 10^{-3}$ mol [1]

$n_C : n_H : n_O = 3 : 6 : 1$ [1]

Empirical formula: C_3H_6O [1]

c) Determine the oxidation state of the metal atom or atoms in the following species.

(i) MnO_4^{2-}

[1 mark]

Answer: $-2 - (-2) \times 4 = +6$ [1]

(ii) $K_2Cr_2O_7$

[2 marks]

Answer: K: $+1$ [1]

Cr: $(-2 - (-2) \times 7) \div 2 = +6$ [1]

d) Write a balanced chemical equation in which Fe^{2+} is oxidised to Fe^{3+} by MnO_4^- in an **acidic aqueous solution** and in which the Mn is reduced to a species with oxidation state +2. Your equation must balance for both atoms and charge, and you may **not** use free electrons (e^-) to achieve this.

[4 marks]

Answer: $Fe^{2+}(aq) \longrightarrow Fe^{3+}(aq) + e^-$

$MnO_4^-(aq) + 5e^- + 8H^+(aq) \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$

$\Rightarrow$ $5Fe^{2+}(aq) + 8H^+(aq) + MnO_4^-(aq) \longrightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$

[4] if all correct

If not, $\underline{5}\,Fe^{2+} \rightarrow \underline{5}\,Fe^{3+}$ [1]

$MnO_4^- \rightarrow Mn^{2+}$ [1]

Biology Admissions Assessment Answers 2018

B1

a) Sketch a simple diagram of a eukaryotic cell, and label the locations where DNA transcription and RNA translation take place (2 Marks)

A. Students should draw a simple diagram, with transcription labelled in the nucleus (1 Mark) and translation on free or attached ribosomes in the cytoplasm (1 Mark)

b) When RNA is translated into proteins, it is read in triplets (codons). What proportion of codons might be viewed as redundant in the genetic code (i.e. in excess of the minimum needed to make all amino acids)? (2 Marks)

A: 44/64 (one Mark for numerator and one Mark for denominator)

c) What is an advantage of having more codons in the genetic code than there are amino acids? (2 Marks)

A: Point mutations may lead to same amino acid (1 Mark), which gives increased fault tolerance (1 Mark).

d) A ribosome can translate 18 bases per second. How many seconds would it take to produce a protein that was 299 amino acids long? (2 Marks)

A: 897/18, or 49.833 (one Mark for 299x3, one Mark for calculation)

e) Imagine that an alien organism is found that translates its RNA using pairs of nucleotides instead of triplets. During translation, the alien organism can produce 50 possible amino acids. What is the minimum number of different types of nucleotides that would be needed to produce all of the amino acids? (2 Marks)

A: 8 (8^2 =64, 2 Marks for correct answer)

f) Using examples, describe the changes that can occur in DNA sequences and how these can lead to genetic diseases. (10 Marks)

A: 2 Marks each for explaining the importance of the following, with mention of the effects that they can have:

Substitution (change in aas, premature chain termination)

Deletion (loss of aas, genes + frameshifts)

Insertion (gain in aas, frameshifts)

2 Marks for each of two specific examples of diseases (with some detail)

B2

a) Describe one benefit and one problem associated with using quadrats in a study like this. (2 Marks)

A: Benefit: increased speed/lower effort (1 Mark)
Problem: Sample error (1 Mark)

b) Calculate the frequency of occurrence of the species in the quadrats. (1 Mark)

A. 6/8 (1 Mark)

c) Calculate the mean number of plants found per square metre in the quadrats (1 Mark)

A. 12/32 (1 Mark for mean per quadrat, 1 Mark for mean per metre)

d) For the field as a whole, the population grows by 70 individuals per week. How long will the population take to reach an average density of two plants per square metre in the whole field? (2 Marks)

A. 25 days (1 Mark for calculating final number of plants, 1 Mark for calculating time)

e) This invasive plant only produces flowers every 5 years. Why might this occur? (3 Marks)

A. One Mark each for identifying:
Importance of synchrony with pollinators
Importance of asexual reproduction
Importance of resource build-up
(or 1 Mark for other sensible ideas)

f) Discuss the factors that may affect the spread and photosynthetic rate of the plant. (10 Marks)

A. 2 Marks for discussing each of the following (up to a maximum of 10):
Limits to transmission (e.g. vectors for pollen, seeds)
Limitations on spread from competition (inter-specific)
Limitations on spread due to reproduction/growth rate
Limitations on spread do to environmental conditions
Effects of light intensity on photosynthesis
Effects of C02 levels on photosynthesis
Effects of temperature on photosynthesis
+ Any other sensible idea not related to the above

To get the full 2 Marks for each topic, students should have a level of specificity in their answers and not just state that a factor "has an effect". For the photosynthetic element, graphs or detailed descriptions are expected.