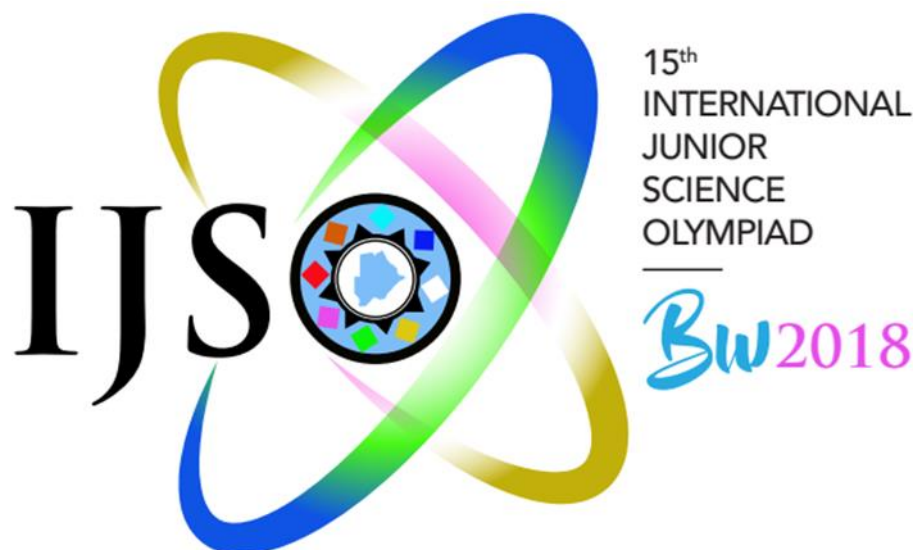


15TH INTERNATIONAL JUNIOR SCIENCE OLYMPIAD

IJSO-2018



Discovery, Innovation and Environment

Theory Competition

MARKING GUIDE

– Exam Sheet –

December 6, 2018

**Do NOT turn to next page
before a whistle is blown.**

Otherwise, you will receive a penalty.

1. You have 10 minutes to read “EXAMINATION RULES”, “EXAM INSTRUCTIONS”, and “CALCULATOR INSTRUCTIONS” on pages 1 - 3.

2. Do NOT start answering the questions before the “START” whistle! Otherwise, you will receive a penalty.



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Time : 3 hr

Points : 30

Page 1

QUESTIONS

EXAMINATION RULES

1. You are NOT allowed to bring any personal items into the examination room, except for personal medicine or approved personal medical equipment.
2. You must sit at your designated desk.
3. Check the stationery items (pen, calculator, and rough book) provided by the organizers.
4. Do NOT start answering the questions before the “START” whistle.
5. You are NOT allowed to leave the examination room during the examination except in an emergency in which case you will be accompanied by a supervisor/volunteer/invigilator.
6. Do NOT disturb other competitors. If you need any assistance, you may raise your hand and wait for a supervisor to come.
7. Do NOT discuss the examination questions. You must stay at your desk until the end of the examination time, even if you have finished the exam.
8. At the end of the examination time you will hear the “STOP” whistle. Do NOT write anything more on the answer sheet after this stop whistle. Arrange the exam, answer sheets, and the stationary items (pen, calculator, and rough book) neatly on your desk. Do NOT leave the room before all the answer sheets have been collected.



QUESTIONS

INSTRUCTIONS FOR CALCULATOR

1. Turning on: Press **ON/C**.
2. Turning off: Press **2ndF** **ON/C**.
3. Clearing data: Press **ON/C**.
4. Addition, subtraction, multiplication, and division

Example 1) $45 + \frac{285}{3}$

ON/C 45 **+** 285 **÷** 3 **=** **140.**

Example 2) $\frac{18+6}{15-8}$

ON/C (18 **+** 6 **)** **÷** (15 **-** 8 **)** **=**
3.428571429

Example 3) $42 \times (-5) + 120$

ON/C 42 **×** 5 **+/-** **+** 120 **=** **-90.**

ON/C 42 **×** (**-** 5 **)** **+** 120 **=** **-90.**

5. Exponential

Example 1) 8.6^{-2}

ON/C 8.6 **y^x** 2 **+/-** **=** **0.013520822**

Example 2) 6.1×10^{23}

ON/C 6.1 **×** 10 **y^x** 23 **=** **6.1 x 10²³**

6. To delete a number/function, move the cursor to the number/function you wish to delete, then press **DEL**. If the cursor is located at the right end of a number/function, the **DEL** key will function as a back space key.



QUESTIONS

**Do NOT turn to next
page
Before
the "START" whistle is
blown.
Otherwise, you will
receive a penalty.**



QUESTIONS

Biology

Q1

- a) Choose two (2) of the gases listed, which are the major constituents of the gas in the bubbles. Write the appropriate letters into the boxes below. **[0.3 marks, 0.15 for each correct answer]**

B	D
---	---

- b) What are the beneficial uses of biogas to man? Write three (3) letters corresponding to uses in the boxes below. **[0.3 marks, 0.1 for each correct answer]**

A	C	D
---	---	---

- c) Decide, whether the following statements regarding that decomposition process are true or false by marking the appropriate box with a cross (X). **[0.4 marks, 0.1 for each correct answer]**

Statement	True	False
The decomposition of plant and animal tissue at the bottom of the swamps is an aerobic process.		X
The gases produced as a result of the degradation are metabolic waste products of bacterial metabolism.	X	
The biochemical decomposition processes of plant and animal matter by bacteria do not require water molecules.		X



QUESTIONS

Bacteria that degrade plant and animal matter at the bottom of the swamp receive more energy from the degradation compared to bacteria decomposing the same plant and animal matter on the surface.		X
---	--	---

- d) What could be the explanation of the observation described? Indicate, which of these options could be true and which ones false by marking the appropriate box with a cross (X). [0.25 marks, 0.05 for each correct answer]

Possible explanation	True	False
The bacteria are able to multiply more rapidly due to the higher temperatures.	X	
The enzymes in the bacteria are working at close to their optimum rate.	X	
More enzyme-substrate complexes are being formed, so more biogas can be made.	X	
The kinetic energy of the enzyme and substrate molecules has decreased.		X
The enzymes in the bacteria have begun to denature.		X

- e) What is the most likely explanation for the observation described? Write the corresponding letter in the box below. [0.25 marks]

B



QUESTIONS

Q2

- a) Use the space given below to calculate the frequencies of the genotypes AA, Aa and aa. **[0.75 marks, 0.25 for each correct answer]**

Calculations

$$[AA] = (350/600) = \mathbf{0.583}$$

$$[Aa] = (100/600) = \mathbf{0.167}$$

$$[aa] = (150/600) = \mathbf{0.250}$$

Frequency of genotype AA:
0.583 [0.25 marks]

Frequency of genotype Aa:
0.167 [0.25 marks]

Frequency of genotype aa:
0.250 [0.25 marks]

- b) Use the space given below to calculate the frequencies of alleles A and a. **[1.0 mark, 0.5 for each correct answer]**

Calculations

$$[A] = ((700 + 100)/1200) = \mathbf{0.6667} \text{ or } [350 + 50 / 600]$$

$$[a] = ((100 + 300) / 1200) = \mathbf{0.3333} \text{ [150+50/600]}$$



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QUESTIONS

Frequency of allele A: 0.6667 [0.5 marks]	Frequency of allele a: 0.3333 [0.5 marks]
--	--



QUESTIONS

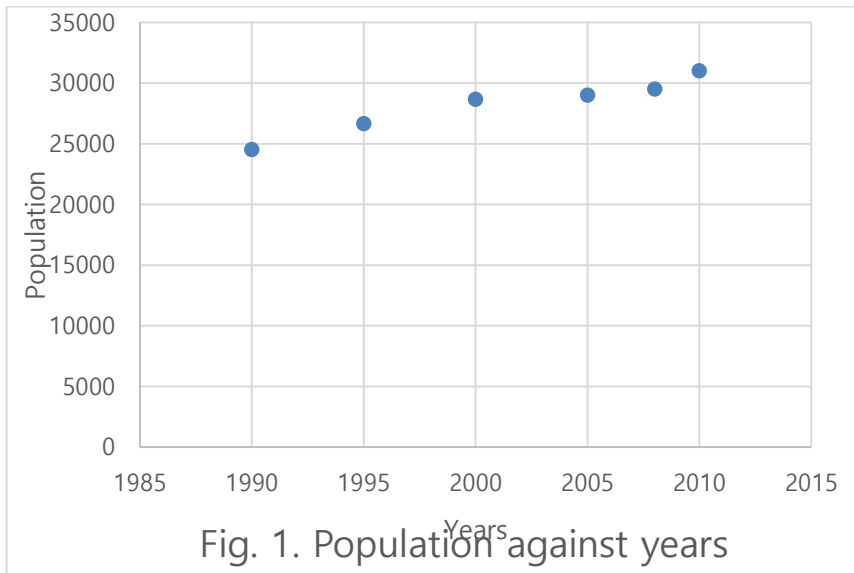
- c) Use the space given below to calculate the expected frequencies of the genotypes AA, Aa and aa if the population was in a genetic equilibrium. **[1.5 marks, 0.5 for each correct answer]**

Calculations		
$[AA] = p^2 = (0.67 * 0.67) = \mathbf{0.449}$		
$[Aa] = 2pq = 2 * 0.67 * 0.33 = \mathbf{0.442}$		
$[aa] = q^2 = 0.33 * 0.33 = \mathbf{0.109}$		
Frequency of genotype AA: 0.449 [0.5 marks]	Frequency of genotype Aa: 0.442 [0.5 marks]	Frequency of genotype aa: 0.109 [0.5 marks]

Q3

- a-1) Plot a graph of population size against year using the graph paper provided **[1.0 marks]**

QUESTIONS



- Marks are as follows:**
- 0.6 correct plotting of points (0.1 for each)**
 - 0.2 labelled axes [0.1 for each correctly labelled axis]**
 - 0.2 scale**

a-2) Draw a linear trendline of your data, determine the equation of the line and write the equation in the box below. **[0.5 marks]**

Calculations

Example of ideal graph line equation calculation:

$$\text{slope} = \frac{y_2 - y_1}{x_2 - x_1} = 286.87$$

Where (x_1, y_1) and (x_2, y_2) are coordinates of any two points on the trend line

To find the intercept, substitute (x_1, y_1) or (x_2, y_2) in $y = mx + c$ and solve for c . note that c is the intercept and m is the slope

[0.25] for correct trend line on student's graph



QUESTIONS

Line equation: **[0.25 marks for correct equation based on the student's graph]**

a-3) Use the space given below to calculate the average growth rate of the elephant population size from 1990 to 2010. **[0.25 marks]**

Calculations

Growth rate is the slope of the trendline or fitted linear line, which is 287 for the ideal graph.

Students need to take the slope from their equation.

Average growth rate:

[0.25 marks if they have taken the correct value and added the correct unit]

a-4) Use the space given below to calculate the projected elephant population size in 2019. **[0.5 marks]**

Calculations

Solved using the ideal trendline equation:

$y = mx + c$ which is in this case, $y = 287x - 545902$

Therefore $y = 287 \times 2019 - 545902 = 33551$

- a) **Students may use their line equation to calculate the value in the way above.**
- b) **Students may take the value for 2010 and add $9 \times$ the annual growth rate.**
- c) **Student may decide to extend the trendline to 2019 then extrapolate the answer for elephant population from the graph.**

The value should be higher than the value for 2010.

Projected population size:



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QUESTIONS



QUESTIONS

- b) Use the space given below to calculate the difference in the density of the elephant population size in 1995 and 2010 in the Chobe National Park. **[0.5 marks]**

Calculations

$$\text{Density} = \frac{\text{number of animals}}{\text{area}}$$

$$\text{Density} = \frac{31000 - 26650}{11700}$$

$$= 0.372 \text{ elephants/km}^2$$

Difference in density: **0.372 elephants/km²**

[0.25 marks for correct answer + 0.25 marks for correct units]

- c) Use the space given below to calculate the total amount of bark that was stripped in 1995. **[0.5 marks]**



QUESTIONS

Calculations

Total food consumed in 1995

$$= 28650 \times 200 \text{ kg/day} \quad [0.125]$$

$$= 5730000 \text{ kg/day} \times 365 \text{ days} \quad [0.125]$$

$$= 2.09145 \times 10^9 \text{ kg} \quad [0.125]$$

The total bark portion of the consumed food is 35%

Therefore 35% of that number is: $\frac{35}{100} \times 2.09145 \times 10^9 \text{ kg}$

$$= 732007500 \text{ kg} \quad [0.125]$$

Total amount of bark stripped: $7,3 \times 10^8 \text{ kg}$

- d) Use the space given below to calculate the percentage of the actual material utilized by the elephant per day. **[0.5 marks]**

Calculations

Actual material utilized = 200kg – 136kg = 64kg [0.2 marks for correct kg value, 0.05 marks for units]

% of the actual material utilized = $\frac{64}{200} \times 100 = 32\%$ [0.2 marks for correct kg value, 0.05 marks for units]

Percentage of actual material utilized: **32%**



QUESTIONS

Q4

Decide, whether each of the terms listed below corresponds to the interior of the membrane (within the membrane) or the exterior surfaces of the membrane and fill in the table. Use „+“ if the term applies and „0“ if the term does not apply. [1.5 marks, 0.125 for each correct answer]

	Interior	Exterior
Hydrophobic	+	0
Hydrophilic	0	+
Fatty acid tails	+	0
Ribosomes	0	0
Ion channels	+	+
Oligosaccharides	0	+

QUESTIONS

Chemistry

Q5 Chemistry: Acid mine drainage and air pollution at a nickel mine

Q5a	(0.5)	<p>Write the balanced equations for the neutralization and precipitation reactions</p> <p style="color: red;">Neutralisation $\text{Ca}(\text{OH})_2 (\text{aq}) + \text{H}_2\text{SO}_4 (\text{aq}) \rightarrow \text{CaSO}_4 (\text{s}) + 2\text{H}_2\text{O} (\text{l})$ [0.25; if not balanced subtract 0.1, don't penalize for state symbols]</p> <p style="color: red;">Precipitation $\text{Fe}_2(\text{SO}_4)_3 (\text{s}) + 3\text{Ca}(\text{OH})_2 (\text{aq}) \rightarrow 2\text{Fe}(\text{OH})_3 (\text{s}) + 3\text{CaSO}_4 (\text{s})$ [0.25; if not balanced subtract 0.1, don't penalize for state symbols]</p>
Q5b	(1.75)	<p>What mass in kilogram of $\text{Fe}(\text{OH})_3$ will be produced due to oxidation of pyrites?</p> <p style="color: red;">Molar mass of $\text{FeS}_2 = 119.97 \text{ g/mol}$ [0.25] Molar mass of $\text{Fe}(\text{OH})_3$ is 106.85 g/mol [0.25] % of pyrite in solid waste = $5/100 \times 10^6 = 5 \times 10^4 \text{g}$ [0.25] Mole of FeS_2 $5 \times 10^4 / 119.97 = 416.78 \text{ mol}$; mole ratio is 1:1 [0.25] Mole of $\text{Fe}(\text{OH})_3$ is 416.78 mol [0.25] Mass of $\text{Fe}(\text{OH})_3$ is then $5 \times 10^4 / 119.97 \times 106.85 = 44533.08 \text{ g} = 44.5 \text{ kg}$ [0.5]</p> <p style="color: red;">[Final answer should be given to the correct significant figure, if not subtract 0.1]</p> <p style="text-align: center;">$\text{Fe}(\text{OH})_3$ mass44.5.....kg</p>

QUESTIONS

5c	(0.5)	<p>How much iron (II) (in grams) is pumped into the chemical neutralization plant in 2 hours at the stated flow rate using red lake water as feed?</p> <p style="color: red;">Volume of iron(II) pumped in two hours = $50.0 \text{ m}^3/\text{h} \times 2 \text{ hours} = 100 \text{ m}^3$ [0.25] Iron(II) mass $100\text{mg/L} \times 100 \text{ m}^3 \times 1000\text{L}/1\text{m}^3$ = 10 000 000 mg = 10 000 g Or = $1.00 \times 10^4 \text{ g}$ [0.25]</p>
		<p>Iron (II) g</p>
5d	(1.0)	<p>How many moles of H^+ ions were neutralized in one liter of solution?</p> <p style="color: red;">pH = $-\text{Log} [\text{H}^+]$ [0.25] At pH 6.0 concentration = $-\text{Log} [\text{H}^+]$; $[\text{H}^+] = 1.00 \times 10^{-6}$ [0.25] At pH 1.9 concentration = $-\text{Log} [\text{H}^+]$; $[\text{H}^+] = 1.26 \times 10^{-2}$ [0.25] Concentration = $1.26 \times 10^{-2} \text{ mol/L}$ Moles of $\text{H}^+ = 1.26 \times 10^{-2} \text{ mol}$ [0.25]</p>
		<p>Moles of acid =</p>
Q5e	5e-1 (0.15)	<p>What is the order of the reaction with respect to iron(II) expressed as a number?</p> <p style="color: red;">1 [0.15]</p>
	e-2 (0.25)	<p>What is the rate of reaction when the surface area of the reactor is doubled at constant volume?</p> <p style="color: red;">Rate = $16.1 \times 2 = 32.2 \text{ molL}^{-1}\text{s}^{-1}$ [0.25]</p>

QUESTIONS

	e-3 (0.5)	<p>What is the rate of reaction when the pressure of oxygen gas is doubled?</p> <p style="text-align: center;">Pressure is $2^{0.5} = 1.41$ [0.25] Rate = $16.1 \times 1.41 = 22.7 \text{ molL}^{-1}\text{s}^{-1}$ [0.25]</p>
Q5f	(2.0)	<p>What mass in tons of calcium carbonate is needed to remove one ton of sulphur dioxide if the removal process is 90.0% efficient?</p> <p style="text-align: center;">Moles of $10^6 / 64.06 = 15610.37 \text{ mol}$ [0.25] Mol ratio $\text{CaCO}_3:\text{SO}_2 = 1:1$ [0.25] Mol of $\text{CaCO}_3 = 15610.37 \text{ mol}$ [0.25] Mass of $\text{CaCO}_3 = 15610.37 \times 100.09 = 1562441.93 \text{ g}$ [0.25] Mass in ton = $1562441.93 / 10^6 = 1.56 \text{ t}$ (for 100 % efficiency) [0.5] a) $90\% = 1.56 \text{ t} / 0.9 = 1.73 \text{ t}$ [0.25] b) Total amount of CaCO_3 needed = $1.73 / 0.65 = 2.66 \text{ t}$ [0.25]</p>
Q5g	(0.6)	<p>Calculate the number of moles of CO_2 gas present in the container after 20 minutes of heating</p> <p>($R = 0.082 \text{ L}\cdot\text{atm}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$; $R = 8.314 \text{ J}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$), $1 \text{ atm} = 101325 \text{ Pa}$.</p> <p style="text-align: center;">$PV = nRT$</p> <p style="text-align: center;">$n = \frac{PV}{RT}$ [0.1]</p> <p style="text-align: center;">$n = \frac{1.04\text{atm} \times 1.00\text{L}}{0.082 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \times 1100\text{K}}$ [0.25]</p> <p style="text-align: center;">$= 0.0115 \text{ mol}$ [0.25]</p>

QUESTIONS

Q5h	h-1 (0.25)	<p>What will be the final pressure inside the container?</p> <p>Tick the correct answer</p> <table border="1" style="width: 100%;"> <tbody> <tr> <td style="width: 80%;">Less than 1.04 atm</td> <td style="width: 20%;"></td> </tr> <tr> <td>greater than 1.04 atm</td> <td></td> </tr> <tr> <td>Equal to 1.04 atm</td> <td style="text-align: center; color: red;">✓</td> </tr> </tbody> </table>	Less than 1.04 atm		greater than 1.04 atm		Equal to 1.04 atm	✓
	Less than 1.04 atm							
greater than 1.04 atm								
Equal to 1.04 atm	✓							
h-2 (0.25)	<p>Where will the equilibrium shift to in the reaction equation below?</p> <p>Tick the correct answer</p> <table border="1" style="width: 100%;"> <tbody> <tr> <td style="width: 80%;">Right (product side)</td> <td style="width: 20%;"></td> </tr> <tr> <td>Left (reactant side)</td> <td style="text-align: center; color: red;">✓</td> </tr> <tr> <td>No change</td> <td></td> </tr> </tbody> </table>	Right (product side)		Left (reactant side)	✓	No change		
Right (product side)								
Left (reactant side)	✓							
No change								
Q5i	(0.25)	<p>Calculate the value of the equilibrium constant, K_p, for the decomposition of CaCO_3 at 1100 K.</p> <p style="text-align: center; color: red;">$K_p = P_{\text{CO}_2} = 1.04 \text{ atm (or 105378 Pa)}$</p> <p style="text-align: center; color: red;">[award 0.1 for the K_p expression and 0.15 for the answer]</p>						

QUESTIONS

6	(1.5)	<p>What mass in kilogram of sodium carbonate can be formed from 0.850 ton of trona?</p> <p style="text-align: center;"> Molar mass of trona = 332 g/mol [0.25] Moles of trona = $0.85 \times 10^6 \text{ g} / 332 \text{ g/mol} = 2.56 \times 10^3 \text{ moles}$ [0.25] 5 moles of Na_2CO_3 : 2 moles of Trona [0.25] Moles of $\text{Na}_2\text{CO}_3 = 2.56 \times 10^3 \times 5/2 = 6.4 \times 10^3 \text{ moles}$ [0.25] Molar mass of $\text{Na}_2\text{CO}_3 = 106 \text{ g/mol}$ [0.25] Mass of $\text{Na}_2\text{CO}_3 = 6.4 \times 10^3 \text{ moles} \times 106 \text{ g/mol} = 6.78 \times 10^5 \text{ g} = 678 \text{ kg}$ [0.25] </p>
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7	(0.5)	<p>What is the concentration of carbonic acid in air saturated with water vapour at 25 °C?</p> <p style="text-align: center;"> Henry's law is $\text{Conc} = KP$ $= 2.3 \times 10^{-2} \text{ mol/L.atm} \times 3.04 \times 10^{-4} \text{ atm}$ [0.25] $= 7.0 \times 10^{-6} \text{ mol/L}$ [0.25] </p>
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QUESTIONS

Total points for question Q5a	
Total points for question Q5b	
Total points for question Q5c	
Total points for question Q5d	
Total points for question Q5e	
Total points for question Q5f	
Total points for question Q5g	
Total points for question Q5h	
Total points for question Q5i	
Total points for question Q6	
Total points for question Q7	
Total marks	

QUESTIONS

Physics Theory answer sheet

No unit in final answer: -0.1		
Questions	Points	Waves: Doppler effect: Answers (show your working)
Q6	(1.40)	<p>Calculation of frequency as the ambulance approaches the observer Step 1: calculate v_s (note speed of sound increases as temperature increases) $v_s = 331.3 + 0.606 * T_C = 331.3 + 0.606 * 38 = 354.328 \text{ m/s}$ [0.20]</p> <p style="text-align: center;">ambulance approaching the observer</p> <p>convert 90 km/h = 25 m/s [0.25]</p> <p>$f_o = f_s \left(\frac{v_s}{v_s - v_o} \right)$ correct equation!! [0.45]</p> <p>$f_o = 300.0 * \left(\frac{354.328}{354.328 - 25} \right)$ [0.25]</p> <hr style="border: 0.5px solid black;"/> <p style="text-align: center;"><i>Approaching ambulance</i> $f_o = 322.77 \text{ Hz}$ [0.25]</p>
Q7	(1.55)	<p>(Show your working)</p> <p>Kinematics During reaction time: Calculation of the acceleration of the car if it stops just before hitting the cow.</p> <p>Initial velocity u $u = 33.2 \text{ m/s}, \quad a = 0, t = 0.20\text{s}$ [0.20]</p> <p>$s = ut + \frac{1}{2}at^2$ [0.25]</p> <p>$s = 33.2 \text{ m/s} * 0.2\text{s} + 0 = 6.64\text{m}$ = distance covered during the reaction time</p> <p>For acceleration; $s = 60\text{m} - 6.64\text{m} = 53.36\text{m}$ [0.25]</p>

QUESTIONS

		<p><i>note that $v = 0 \text{ m/s}, u = 33.2 \text{ m/s}$</i></p> <p>$v^2 = u^2 + 2as$ [0.25]</p> <p>$a = \frac{v^2 - u^2}{2s}$ [0.20]</p> <p>$a = \frac{0 - 33.2^2}{2 * 53.36}$ [0.20]</p> <p>$a = -10.3 \text{ m/s}^2$</p> <p>In case of missing “-“ sign: -0.10</p>	
		<p>acceleration of the car = $a = -10.3 \text{ m/s}^2$ [0.20]</p>	



QUESTIONS

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Fluid flow: conservation of energy and continuity principles		
Question s	Point s	Answers (show your working)
Q8 (a)	(0.85)	Calculate the velocity of water through the pipe at the farm <i>from the continuity equation $Q = A_1 v_1 = A_2 v_2$</i>
		Note $A = \pi R^2 = \pi \frac{D^2}{4}$ [0.20]
		$v_2 = \frac{A_1 v_1}{A_2} = \frac{\pi D_1^2 / 4}{\pi D_2^2 / 4} * v_1$ [0.25]
		$v_2 = \frac{\pi * 0.35^2}{\pi * 0.25^2} * 1.30$ [0.20]
		$v_2 = 2.55 \text{ m/s}$ [0.20]
Q8 (b)	(0.9)	

QUESTIONS

		<p><i>Calculation of the pressure of water at the farm</i></p> <p><i>Consider Bernoulli's equation</i></p> $\frac{P}{\rho} + \frac{1}{2}v^2 + gy = \text{constant}$ <p>Or $P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$ [0.20]</p> $P_2 = P_1 + \frac{1}{2}\rho(v_1^2 - v_2^2) + \rho g(y_1 - y_2)$ [0.25] $P_2 = 670000 + \frac{1}{2}(1000) * (1.30^2 - 2.55^2) + 1000 * 9.8 * (940 - 960)$ $P_2 = 670000 - 2401.152 - 196000$ [0.25]
		<p><i>Pressure P_2 at the farm = 471598.8 Pa = 471598.8 N/m²</i> [0.20]</p>

QUESTIONS

Q8 (c)	(0.8)	<p>Flow rate at the farm $Q = A_2 v_2 = \frac{\pi D_2^2}{4} v_2$ [0.20]</p> <p>$Q = \frac{\pi 0.25^2}{4} 2.55 = 0.125 \text{ m}^3/\text{s}$ [0.10]</p> <p>Calculation of time it takes to fill a 50000L reservoir</p> <p><i>Convert</i> $L \rightarrow m^3$</p> <p>$50000L = 50m^3$ [0.10]</p> <p>$Time \text{ taken} = \frac{50m^3}{0.125m^3/s}$ [0.20]</p>
		<p>$t = 400 \text{ sec}$ [0.20]</p>

QUESTIONS

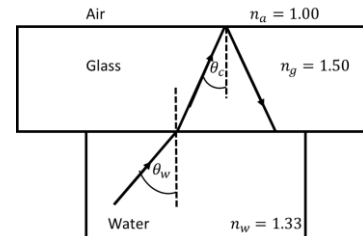
Q9	(1.9)	<p>ELASTIC COLLISIONS</p> <p><i>Momentum before collision = momentum after collision</i></p> $m_A u_A = m_A v_A + m_B v_B \quad [0.25]$ <p>After collision: $x = v_x t$; horizontal distance</p> $x_A = 1\text{m} = v_{xA} t \quad \text{distance travelled by ball A} \quad [0.20]$ $x_B = 2\text{m} = v_{xB} t \quad \text{distance travelled by ball B} \quad [0.20]$ <p>Vertical Motion:</p> $y = u_y t - \frac{1}{2} g t^2 \quad [0.20]$ $u_y = 0 \text{ hence}$ $-1.225 = -\frac{1}{2} * 9.8 * t^2$ $t = \sqrt{\frac{1.225}{4.9}} = 0.50\text{s} \quad [0.25]$ $x_A = 1 = v_{xA} t = 0.5 v_{xA}$ $v_{xA} = 2.0 \text{ ms}^{-1} \quad [0.20]$ $x_B = 2 = v_{xB} t = 0.5 v_{xB}$ $v_{xB} = 4.0 \text{ ms}^{-1} \quad [0.20]$ $m_A u_A = m_A v_A + m_B v_B$ $u_A = \frac{m_A v_A + m_B v_B}{m_A} \quad [0.20]$
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QUESTIONS

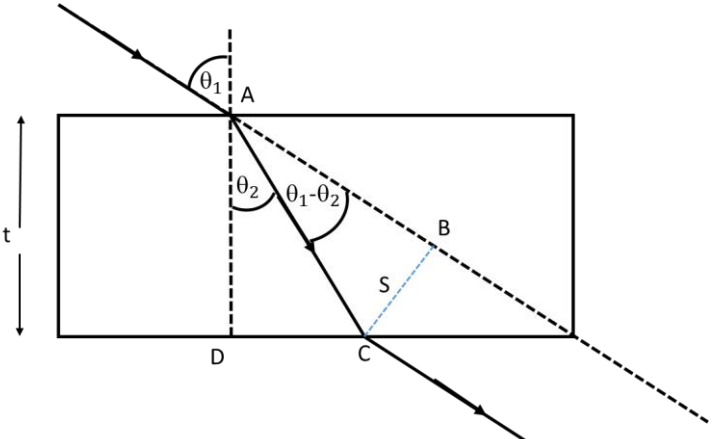
Q9	(1.9)	<p><i>Mass can be used in g or kg:</i></p> $u_A = \frac{0.060 * 2 + 0.020 * 4}{0.060} = 3.33 \text{ m/s}$ <p><i>Velocity before impact= 3.33 m/s</i> [0.20]</p>
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QUESTIONS

<p>Q10a</p>	<p>1.1</p>	<p>For minimum angle θ_w, angle of incidence at the glass- air boundary is the critical angle θ_c.</p> <p>From Snell's law (steps 1-3): $n_g \sin \theta_c = n_a \sin 90$ [0.20]</p> $\sin \theta_c = \frac{n_a}{n_g} = \frac{1}{1.5}$ [0.10] $\theta_c = \sin^{-1} \left(\frac{1}{1.5} \right) = 41.8^\circ$ [0.20] <p>At water- glass surface interface</p> $n_w \sin \theta_w = n_g \sin \theta_c$ [0.20] $\sin \theta_w = \frac{n_g \sin \theta_c}{n_w} = \frac{n_g}{n_w} * \frac{n_a}{n_g}$ $\theta_w = \sin^{-1} \left(\frac{n_g}{n_w} * \frac{n_a}{n_g} \right) = \sin^{-1} \left(\frac{n_a}{n_w} \right) = \sin^{-1} \left(\frac{1}{1.33} \right)$ [0.20] <p>Students will not be penalized for not using step 1-3 when final answer is correct</p> <p>Final answer:</p> $\theta_w = 48.8^\circ$ [0.20] <p>Illustration showing incident, transmitted and emergent ray and labelling</p>
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QUESTIONS

<p>Q10b</p>	<p>1.5</p>	<p>of slab thickness [0.4]</p>
		<p>Correct labelling of angles θ_1 and θ_2 [0.2]</p>
		
<p>From triangle ABC, $\frac{BC}{AC} = \sin(\theta_1 - \theta_2)$ [0.20]</p>		
<p>From triangle ADC, $\frac{AD}{AC} = \cos(\theta_2)$ [0.20]</p>		
<p>Therefore $AC = \frac{AD}{\cos(\theta_2)} = \frac{t}{\cos(\theta_2)}$ [0.20]</p>		
<p>$\sin(\theta_1 - \theta_2) = \frac{BC}{AC} = \frac{BC \cdot \cos(\theta_2)}{t}$</p>		
<p>That is:</p>		
<p>$BC \cdot \cos(\theta_2) = t \cdot \sin(\theta_1 - \theta_2)$ [0.20]</p>		
<p>$BC = s = \frac{t \cdot \sin(\theta_1 - \theta_2)}{\cos(\theta_2)}$ [0.10]</p>		



QUESTIONS

----- DO NOT WRITE BELOW -----

Total points for question Q6	
Total points for question Q7	
Total points for question Q8	
Total points for question Q9	
Total points for question Q10	
Total marks	