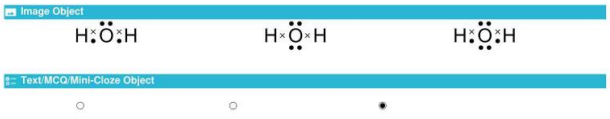
Question		Answers	Notes	Total	Criterion
1	a	***Accept any ~~of the following~~ [1 max]:*** • any noble gas • any element ~~from 209 to 280~~ • any actinide or lanthanide except Th or U • Sc or Ga or Ge or Hf		**1**	A
	b	lanthanides or actinides very small quantities of these elements exist ***or*** many are not naturally occurring ***or*** noble / inert gases / group 0 / group 18 / group VIII unreactive ***or*** not found in compounds **or** technology not available to isolate them	*Reason should be correctly linked to named group*	**2**	A
	c	Number of protons = 26 Number of neutrons = 32		**2**	A
	d	Iron / Fe	*ecf from part (c)*	**1**	A

2	a		*Check the position of the dot carefully, it is not always aligned directly under the correct structure*	**1**	A
	b	4 NO_2 (g) + O_2 (g) + 2 H_2O (l) → 4 HNO_3 (aq) ***First mark:*** any two coefficients are correct ***Second mark:*** all coefficients are correct		**2**	A
	c	acidic ***or*** contains an acid ***or*** low pH		**1**	A
	d	Group 6 Period 3	*Do **not** award any marks if the group and period are switched*	**2**	A
	e	98 ***or*** 0.098 g ***or*** kg	*Accept $gmol^{-1}$* *Award unit mark separately* *unit and value must agree*	**2**	A
	f	Class: Ester Name: Ethyl ethanoate Class: Alcohol Name: Propan-1-ol		**4**	A

3	a	***Any two from the list [2 max]:*** • good thermal / heat conductivity • malleable • high melting point • rigid / solid	*Do **not** accept conductivity alone, high boiling point, long lasting*	**2**	A
	b	+3 ***or*** 3+ <u>Oxidized</u> (because) electrons are lost from the Al atom ***or*** (because) oxidation state or number increases	*Award marks independently* *Accept half equation showing oxidation but the word oxidized must also be seen*	**3**	A
	c	covalent ***and*** metallic Teflon™ forms a protective coating (metals can produce) ions which are soluble ***or*** Teflon™ is not soluble coating prevents ions from forming ***or*** avoids health issues from ions	*Ignore polar*	**4**	A

4	a	***Any one of the following [1 max]:*** • constant colour (of solution) • volume or amount of water • type of glass or cup		**1**	B
	b	the time taken for diffusion to be complete decreases the kinetic energy increases with increasing temperature so the tea "particles" mix with the water molecules more quickly ***or*** diffusion occurs more quickly	*WTTE* *Award marks independently*	**3**	B
	c	400 ± 10 (seconds) seconds / s	*Award separately*	**2**	C
	d	record data points at intermediate temperatures carry out more than one trial calculate an average		**3**	C

5	a	1 cm^3 pipette		**1**	B
	b	10.666666 (s) 10.7 (s)	*Award two marks if only 10.7 is seen* *Please check table for 10.7 in addition to response box*	**2**	C

	c	 ***scale*:** evenly spaced increments that start at zero ***x axis:*** bubble mixture ***y axis*:** lifespan ***y axis unit*:** s ***Plotting*:** additional mark for all points plotted correctly ***Title*:** correctly links dependent and independent variable		**6**	C
	d	***Independent variable*:** volume of glycerine ***Dependent variable*:** lifespan of bubble		**2**	B

	e	bubbles are different sizes in method 2/ wand ***or*** bubbles are moving in method 2/wand and are static in method 1/straw ***or*** bubbles are affected differently by gravitational field in method 2/wand bubbles in method 2/wand are not reproducible bubbles in method 1/straw will give the most reliable data	*Method 1 uses a straw to form the bubble on a bench* *Method 2 uses a wand*	**3**	C
	f	convert 1 min 10 seconds to 70 ***and*** 1¼ min to 75 seconds method of calculation of mean is seen final answer 74 (s)	 *Award 2nd mark independently (mean can be incorrect)* *no ecf award full marks is correct answer is seen* *accept 1 min 14 s*	**3**	C
	g	not valid because the two additives show different trends sugar causes a decrease in the lifespan of the bubble	 *WTTE*	**2**	C

<table>
<tr><td>6</td><td>a</td><td>
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<tr><th></th><th>1</th><th>2</th><th>3</th><th>4</th></tr>
<tr><td>1.V

(Variables)</td><td>either independent or dependent variable is identified</td><td>independent and dependent variables are identified</td><td></td><td></td></tr>
<tr><td>2.CV

(Control variables)</td><td>one control variable is stated</td><td>two control variables are stated</td><td></td><td></td></tr>
<tr><td>3.E
(Equipment)</td><td>straw or wand and bubble mix are listed</td><td>straw or wand and bubble mix
and
timer or measuring equipment are listed</td><td>straw or wand and bubble mix
and
timer and measuring equipment are listed</td><td></td></tr>
<tr><td>4. Meth

(Method)</td><td>• make bubbles</td><td>• make bubbles
• add at least one additive mentioned
• time (until they burst)</td><td>• make bubbles
• all additives are mentioned
• time until they burst</td><td>• make and measure a bubble solution
• all additives are measured and added
• time until bubble bursts</td></tr>
<tr><td>5. Meas

(Measurements)</td><td>time for one additive is measured</td><td>time for one additive is measured and size of bubble controlled</td><td>time for all additives is measured and the size of the bubble is controlled</td><td></td></tr>
<tr><td>6. D

(Sufficient data)</td><td>at least three trials for an additive</td><td>at least three trials for all additives</td><td>at least three trials for all additives and plans to calculate average</td><td></td></tr>
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</td><td>17</td><td>B</td></tr>
<tr><td></td><td>b</td><td>Graph C</td><td>Accept Graph A</td><td>1</td><td>C</td></tr>
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<td>7</td>
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<tr><th></th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>1.L

(Impact of landfills)</td><td>mention of landfills</td><td>with recycling only 10 % of waste goes to landfills or there is a 90% reduction in waste going to landfill with recycling</td><td></td></tr>
<tr><td>2.P

(Effects of pollution)</td><td>if plastics are recycled or re-used there will be less plastic polluting the environment
or
when plastics are used to generate electricity they are removed and will not pollute the environment</td><td>if plastics are not recycled there will be more plastic polluting the environment
and
when plastics are used to generate electricity they are removed and will not pollute the environment</td><td></td></tr>
<tr><td>3.B

(use of by-products)</td><td>if plastics are re-used or recycled useful by-products are produced
or
plastics can be recycled and used to generate electricity</td><td>if plastics are re-used or recycled useful by-products are produced
and
plastics can be recycled and used to generate electricity</td><td>if plastics are re-used or recycled useful by-products are produced
and
plastics can be recycled and used to generate electricity
and
plastics which are not recycled produce no useful by-products</td></tr>
<tr><td>4.R

(Re-use of raw materials)</td><td>same amount of raw material is consumed or lost whether or not the plastic is recycled</td><td></td><td></td></tr>
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<td>8</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td>Any two reasonable responses, for example [2 max]:
• can be reused
• can be recycled at the end of life
• less material is processed
• product can put back into washed bottles
• fewer chemicals are released to the environment
• economic benefits or decrease in production costs

WTTE</td>
<td>2</td>
<td>D</td>
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8							17	D

	1	**2**	**3**	**4**
1. Eff **(Efficiency - to what extent are ions removed can be positive or negative)**	efficiency of one method	efficiency of both methods	efficiency of both methods compared to each other	efficiency of both methods with comparison compared to each other ***and*** scientific justification
2. Env **(Environmental impact)**	environmental impact of one method	environmental impact of both methods	environmental impact of both methods with scientific reasoning for both	
3.Eco **(Economic impact)**	economic impact of one method	economic impact of both methods		
4.G **(Green chemistry)**	one aspect of green chemistry is mentioned eg preventing waste, being energy efficient, using renewable raw materials	two aspects of green chemistry are mentioned eg preventing waste, being energy efficient, using renewable raw materials		
5.C **(Complexity)**	complexity of one method	complexity of both methods	complexity of both methods with comparison	complexity of both methods with comparison ***and*** scientific justification
6. F **(Final choice)**	final choice stated	final choice with justification		