Exam Simulation

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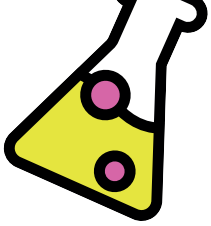
SCIENCE AND TECHNOLOGY (ST)
Part B

Constructed-Response Questions

INSTRUCTIONS

Answer questions 1 to 5, showing all your work for each question.
Each question is worth 4 points.
Refer to the list of formulas and quantities on page 7.
Check your answers against the answer key on page 8.

Question 1



Global warming has a number of consequences for the environment, including the melting of glaciers and pack ice. This in turn has several consequences.

a) Which of the following is **not** a consequence of the melting of **glaciers**? Put a check mark next to your answer and explain your reasoning.

- ☐ Rise in sea levels
- ☐ Reduced albedo effect
- ☐ Disruption of thermohaline circulation
- ☐ Increase in ocean water salinity

Explanation

_____

_____

b) Which of the following is **not** a consequence of the melting of **pack ice**? Put a check mark next to your answer and explain your reasoning.

- ☐ Changes in navigable waterways
- ☐ Rise in sea levels
- ☐ Disruption of thermohaline circulation
- ☐ Decrease in ocean water salinity

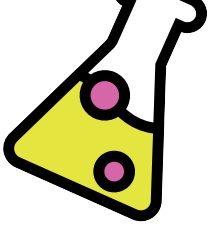
Explanation

_____

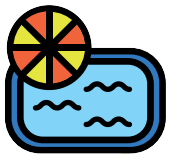
_____

a)	Correct answer	1	0
	Explanation	1	0
b)	Correct answer	1	0
	Explanation	1	0

Question 2



Every Saturday, you work at your local municipal swimming pool. Your manager asks you to measure the concentration of free chlorine in the pool water. This test should be done once a week to ensure that the water is properly disinfected. The ideal concentration of free chlorine is between 2.00 and 4.00 parts per million (ppm). Too low a concentration allows bacteria to multiply, while too high a concentration can irritate swimmers' skin.



In a 1 355 mL sample of pool water, you measure 2.23 mg of free chlorine. Calculate the concentration of free chlorine in parts per million, then recommend a course of action.

The free chlorine concentration is _____

Recommended action

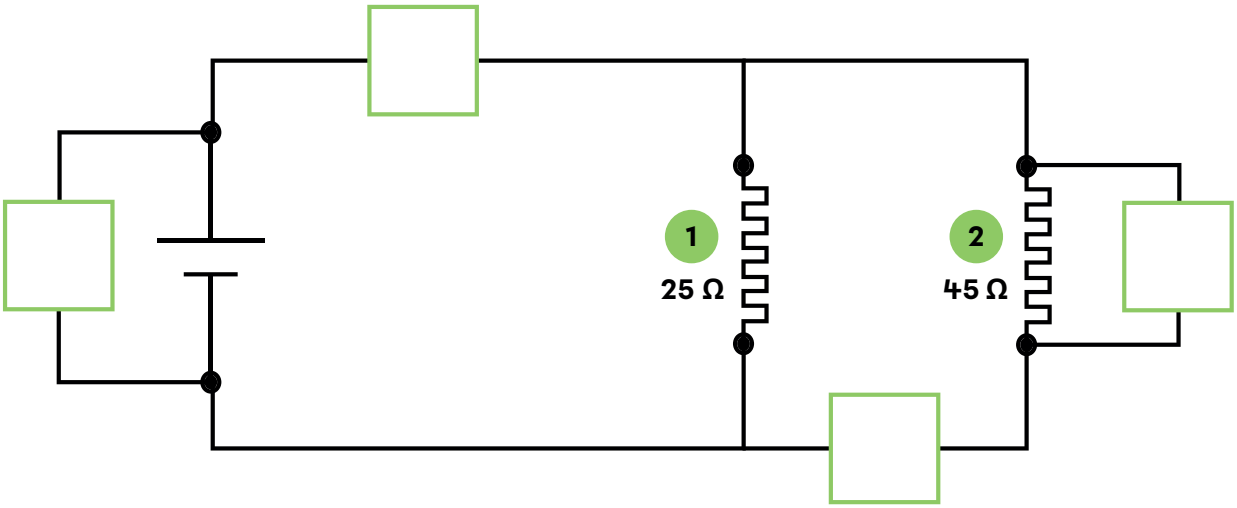
- ☐ No action required, test water again in 1 week.
- ☐ Add chlorine tablets.
- ☐ Add new water from the municipal network.

Appropriate method and correct answer	3	
Appropriate method with one error	2	
Method with at least one appropriate step	1	
Inappropriate or no method	0	
Recommended action	1	0

Question 3

a) In the following circuit diagram, add:

- A voltmeter to measure the potential difference across the terminals of heating element 2
- An ammeter to measure the intensity of the current flowing through the source



b) If the voltmeter you added in a) measures a potential difference of 1.50 V, what is the electric current intensity flowing through heating element 2?

The electric current intensity flowing through heating element 2 is _____

a)	Voltmeter	1	0
	Ammeter	1	0
b)	Appropriate method and correct answer	2	
	Method with at least one appropriate step	1	
	Inappropriate or no method	0	

Question 4

The reaction of 159.70 g of iron(III) oxide (Fe_2O_3) with 36.03 g of carbon (C) produces 111.70 g of iron (Fe) and an unknown amount of carbon monoxide (CO) according to the following unbalanced chemical equation.

Fe_2O_3	+	C	⟶	Fe	+	CO
159,70 g		36,03 g		111,70 g		? g

a) Add the stoichiometric coefficients needed to balance the chemical equation.

Balanced equation:

☐ Fe_2O_3 + ☐ C ⟶ ☐ Fe + ☐ CO

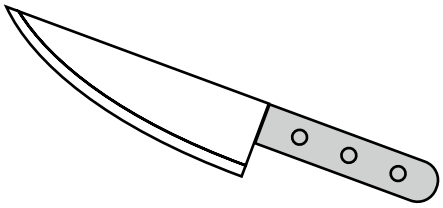
b) Calculate the mass of carbon monoxide (CO) produced during the chemical reaction.

The mass of carbon monoxide (CO) produced is _____

a)	The equation is balanced.	2
	The equation is balanced, but the equation notation rules were not followed.	1
	The equation is not balanced.	0
b)	Appropriate method and correct answer	2
	Method with at least one appropriate step	1
	Inappropriate or no method	0

Question 5

Here is a construction diagram for a kitchen knife.



Materials Legend

- ☐ Ceramic
- ☐ Thermosetting plastic

From the following list, choose a property that justifies the choice of each material, then explain your answer.

chemical neutrality	*electrical conductivity*	*malleability*
corrosion resistance	*fragility*	*resilience*
ductility	*hardness*	*stiffness*
elasticity	*lightness*	*thermal conductivity*

a) Material chosen for the **blade**: ceramic

Property: _____

Explanation

_____

_____

b) Material chosen for the **handle**: thermosetting plastic

Property: _____

Explanation

_____

_____

a)	Property	1	0
	Explanation	1	0
b)	Property	1	0
	Explanation	1	0

List of Formulas and Quantities

Formulas

$$C = \frac{m}{V}$$

C : concentration
m : quantity of solute
V : quantity of solution

$$P = VI$$

P : electrical power
V : potential difference
I : electric current intensity

$$V = RI$$

V : potential difference
R : resistance
I : electric current intensity

$$E = P\Delta t$$

E : energy consumed
P : electrical power
Δt : time difference

$$\text{Energy efficiency (\%)} = \frac{\text{Amount of useful energy}}{\text{Amount of energy consumed}} \times 100$$

Quantities

Name	Symbol	Value
Density of water	ρ	1.0 g/mL 1.0 kg/L 1000 kg/m^3
Kilowatt hour	kWh	1 kWh = 3 600 000 J

Answer Key

Question 1

a) ✓ Increase in ocean water salinity
Explanation: Glaciers are made up of freshwater, so their melting leads to a decrease in salinity. (Other formulations are acceptable.)

b) ✓ Rise in sea levels
Explanation: Pack ice float in ocean water, so their melting has no impact on sea level. (Other formulations are acceptable.)

To review these concepts, check out the following concept sheets!		
Glaciers and Pack Ice	Ocean Circulation	Salinity

Question 2

$$m = 2.23 \text{ mg} \times \frac{1 \text{ g}}{1\,000 \text{ mg}} = 0.002\,23 \text{ g}$$

$$V = 1\,355 \text{ mL}$$

$$C = \text{ ? ppm}$$

$$C = \frac{\text{quantity of solute}}{\text{quantity of solution}} \times 1\,000\,000$$

$$C = \frac{0.002\,23 \text{ g}}{1\,355 \text{ mL}} \times 1\,000\,000$$

$$C \approx 1.65 \text{ ppm}$$

Other Possible Method

$$m = 2.23 \text{ mg}$$

$$V = 1\,355 \text{ mL} \times \frac{1 \text{ L}}{1\,000 \text{ mL}} = 1.355 \text{ L}$$

$$C = \text{ ? ppm}$$

$$1 \text{ ppm} \approx \frac{1 \text{ mg}}{\text{L}}$$

$$C \approx \frac{2.23 \text{ mg}}{1.355 \text{ L}}$$

$$C \approx 1.65 \text{ ppm}$$

Answer: The free chlorine concentration is approximately 1.65 ppm.

Recommended Action

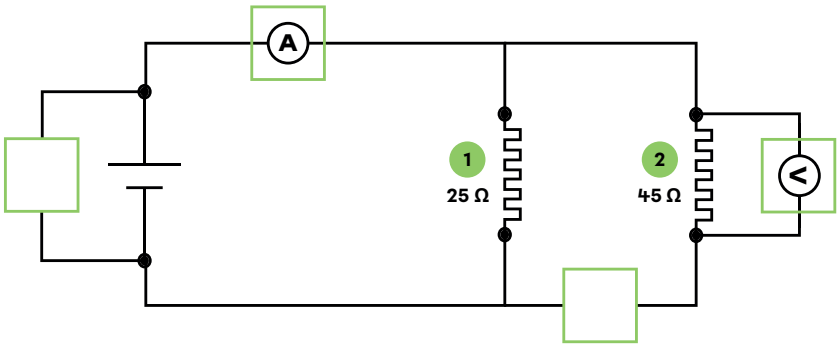
✓ Add chlorine tablets

To review this concept, check out the following concept sheet!
Calculating the Concentration in ppm

Answer Key

Question 3

a) The voltmeter is connected in parallel with heating element 2.
The ammeter is connected in series with the source (battery).



b)

$V = 1.50 \text{ V}$
$R = 45 \ \Omega$
$I = \ ? \text{ A}$

$$V = RI$$
$$\frac{V}{R} = \frac{\cancel{R}I}{\cancel{R}}$$
$$I = \frac{V}{R}$$
$$I = \frac{1.50 \text{ V}}{45 \ \Omega}$$
$$I \approx 0.033 \text{ A}$$

Answer: The electric current intensity flowing through heating element 2 is approximately 0.033 A.

To review these concepts, check out the following concept sheets!	
Electrical Measuring Instruments	Ohm's Law

Answer Key

Question 4

a) Table method

	$\square$ Fe_2O_3	+	3 C	→	2 Fe	+	3 CO
Fe	2	+	0	→	2 x 1 ②	+	0
O	3	+	0	→	0	+	3 x 1 ③
C	0	+	3 x 1 ③	→	0	+	3 x 1 ③

Algebraic method

$$a\mathrm{Fe_2O_3} + b\mathrm{C} \rightarrow d\mathrm{Fe} + e\mathrm{CO}$$

$$\begin{aligned} 2a &= d \\ 3a &= e \\ b &= e \end{aligned}$$

Let's assume that $a = 1$.

$2a = d$
$2 \times 1 = d = 2$

$3a = e$
$3 \times 1 = e = 3$

$b = e = 3$

Balanced equation:

$\square$ Fe_2O_3 + 3 C → 2 Fe + 3 CO

Note: The stoichiometric coefficient for Fe_2O_3 is 1, so the first box is left blank.

b)

$m_{Fe_2O_3} = 159.70\ \text{g}$
$m_C = 36.03\ \text{g}$
$m_{Fe} = 111.70\ \text{g}$
$m_{CO} = \ ?\ \text{g}$

$$m_{\text{reactants}} = m_{\text{products}}$$
$$m_{Fe_2O_3} + m_C = m_{Fe} + m_{CO}$$
$$m_{Fe_2O_3} + m_C - m_{Fe} = m_{CO}$$
$$m_{CO} = 159.70\ \text{g} + 36.03\ \text{g} - 111.70\ \text{g}$$
$$m_{CO} = 84.03\ \text{g}$$

Answer: The mass of carbon monoxide (CO) produced is 84.03 g.

To review these concepts, check out the following concept sheets!	
Balancing a Chemical Equation	Law of Conservation of Matter

Answer Key

Question 5

a) Possible answers for the ceramic blade

Property: Hardness
Explanation: The hardness of the ceramic allows the blade to be sharp.

Property: Stiffness
Explanation: The stiffness of the ceramic prevents the blade from bending when subjected to deflection.

Property: Chemical neutrality
Explanation: The chemical neutrality of the ceramic makes the blade resistant to degradation caused by, for example, acidic foods.

Property: Corrosion resistance
Explanation: The corrosion resistance of the ceramic makes the blade resistant to degradation caused by, for example, acidic foods.

b) Possible answers for the thermosetting plastic handle

Property: Lightness
Explanation: The lightness of thermosetting plastic makes the handle easy to manipulate.

Property: Chemical neutrality
Explanation: The chemical neutrality of thermosetting plastic makes the handle resistant to degradation caused by, for example, acidic foods.

Note: In this context, we can say that thermosetting plastic chosen to manufacture a kitchen knife is chemically neutral. However, it's important to remember that thermosetting plastics generally have **variable** chemical reactivity.

Property: Resilience
Explanation: The resilience of thermosetting plastic makes the handle resistant to shocks.

Property: Corrosion resistance
Explanation: The corrosion resistance of thermosetting plastic means that the handle can withstand degradation caused, for example, by acidic food juices.

Property: Stiffness
Explanation: The rigidity of thermosetting plastic means that the handle does not bend when subjected to deflection.

Answer Key

To review these concepts, check out the following concept sheets!		
Properties of Materials	Ceramics	Plastics