CHEMISTRY
UNIT 1
2021

MARKING GUIDE

Section One: Multiple-choice **(25 marks)**

1	a □ b □ c □ d ■
2	a ■ b □ c □ d □
3	a □ b ■ c □ d □
4	a □ b □ c ■ d □
5	a □ b □ c □ d ■

11	a □ b □ c ■ d □
12	a □ b ■ c □ d □
13	a □ b ■ c □ d □
14	a □ b □ c □ d ■
15	a □ b □ c ■ d □

21	a □ b □ c ■ d □
22	a □ b □ c □ d ■
23	a ■ b □ c □ d □
24	a ■ b □ c □ d □
25	a □ b ■ c □ d □

6	a □ b □ c ■ d □
7	a □ b □ c □ d ■
8	a □ b ■ c □ d □
9	a □ b □ c □ d ■
10	a □ b □ c □ d ■

16	a □ b ■ c □ d □
17	a ■ b □ c □ d □
18	a ■ b □ c □ d □
19	a □ b □ c ■ d □
20	a ■ b □ c □ d □

(1 mark per question)

Section Two: Short answer **35% (80 marks)**

Question 26 **(7 marks)**

(a) Complete the table for the species above. (3 marks)

Description		Marks
Protons	11	1
Neutrons	12	1
Electron configuration	2, 8	1
	Total	**3**

(b) Using the same notation as sodium above, write the symbol for an atomic species that matches each of the following descriptions. (4 marks)

Description		Marks
An alkaline-earth metal in period 4.		1
An anion with the same electron configuration as a neon atom.	$^{3-}$ **or** $^{2-}$ **or** $^{-}$	1
An element in group 15 which exists as a diatomic gas at room temperature.		1
A potassium ion with 22 neutrons.	$^{+}$	1
	Total	**4**

Question 27 **(5 marks)**

Complete the table below, by writing the name of the scientist next to the description of their contribution to atomic theory.

Description		Marks
Proposed that electrons move in circular orbits with particular energy levels.	Bohr	1
Discovered the neutron.	Chadwick	1
Discovered the electron.	Thomson	1
Proposed that atoms of the same element are the same, and atoms of different elements are different.	Dalton	1
Proposed that an atom was largely empty space, with a central nucleus.	Rutherford	1
	Total	**5**

Question 28 **(4 marks)**

Complete the following table, by writing the name of the compound and classifying the compound according to its physical properties.

Description		Marks
H_2SO_3		
Name of compound	sulfurous acid	1
Classification of physical properties	covalent	1
$ZnSO_3$		
Name of compound	zinc sulfite	1
Classification of physical properties	ionic	1
	Total	**4**

Question 29 **(11 marks)**

(a) Define a nanoparticle. (1 mark)

Description	Marks
A particle within the size range 1-100 nm	1
Total	**1**

(b) Give one (1) reason consumers may be concerned about the use of nanoparticles in cosmetics such as face cream. (1 mark)

Description	Marks
Any of the following (or other relevant answer):	
• particles may be more easily absorbed into cells / bloodstream • long terms effects of nanogold unknown • no universal guidelines / recommendations for nanoparticle use	1
Total	**1**

(c) Explain, in terms of electron behaviour, how the gold atoms in the hollow cathode lamp can create an emission spectrum with these unique wavelengths. (5 marks)

Description	Marks
The electrons in gold atoms absorb energy and become excited	1
The electrons move to higher energy levels temporarily	1
The electrons return to their ground state	1
The energy is thus released as light with specific frequencies, creating an emission spectrum	1
The emission spectrum is unique because: the energy shells in each element have slightly different energy levels **or** each element has a different number of electrons	1
Total	**5**

(d) Calculate the number of gold atoms that would be spread over the skin of someone who used 1.0 mL of face cream. (4 marks)

Description	Marks
Absorbance of 0.45 corresponds to a gold concentration of 0.11 mg mL^{-1}	1
In 1 mL of face cream 0.11 mg present; 0.11 mg = 1.1×10^{-4} g	1
n(Au) = $(1.1 \times 10^{-4}) / 197$ = 5.5838×10^{-7} mol	1
N(Au) = $(6.022 \times 10^{23}) \times (5.5838 \times 10^{-7})$ = 3.4×10^{17} atoms	1
Total	**4**

Question 30 **(8 marks)**

(a) Complete the following table, by stating which piece of equipment contains a substance matching the description given. (3 marks)

Description		Marks
A pure substance	Funnel	1
A homogeneous mixture	Beaker 2	1
A heterogeneous mixture	Beaker 1	1
	Total	**3**

(b) Explain why, using an appropriate chemical equation to support your answer. (4 marks)

Description	Marks
Magnesium chloride is an ionic substance	1
When $MgCl_2$ dissolves in water, the ions dissociate	1
This produces mobile charges in the solution, which conduct electricity	1
Equation: $MgCl_2(s) \rightarrow Mg^{2+}(aq) + 2\ Cl^-(aq)$	1
Total	**4**

(c) Name the process that could be used to separate and retain both the components of Beaker 2. (1 mark)

Description	Marks
Distillation	1
Total	**1**

Question 31 **(5 marks)**

Use the information above to complete the table below.

Description		Marks
Element W is likely to be in group	13	1
The element with 6 valence electrons would be	Z	1
The element with the largest atomic radius would be	Y	1
When combined, W and Y are most likely to form	an alloy	1
The compound X_2Z is most likely to contain	covalent bonding	1
	Total	**5**

Question 32 **(7 marks)**

(a) Which antibiotic contains a higher percentage by mass of oxygen? Support your answer with appropriate calculations. (3 marks)

Description		Marks
%O(amoxycillin)	= (80 / 365.402) x 100 = 21.89 %	1
%O(cefalexin)	= (64 / 371.406) x 100 = 17.23 %	1
Therefore, amoxycillin has a higher percent of oxygen		1
	Total	**3**

(b) Calculate the initial mass of amoxycillin that had been analysed. (4 marks)

Description		Marks
$n(NO_2)$	= 0.364 / 46.01 = 0.0079113 mol	1
n(N)	= $n(NO_2)$	1
$n(C_{16}H_{19}N_3O_5S)$	= (1/3) x 0.0079113 = 0.0026371 mol	1
$m(C_{16}H_{19}N_3O_5S)$	= 0.0026371 x 365.40 = 0.964 g	1
	Total	**4**

Alternate working:

%N(amoxycillin)	= (42.03 / 365.40) x 100 = 11.502 %
n(N) = $n(NO_2)$	= 0.364 / 46.01 = 0.0079113 mol
m(N)	= 0.0079113 x 14.01 = 0.11084 g
$m(C_{16}H_{19}N_3O_5S)$	= 0.11084 x (100 / 11.502) = 0.964 g

Question 33 **(11 marks)**

(a) Balance the equation above, by adding the correct coefficients. (1 mark)

Description	Marks
Coefficients: 1, 25, 18, 16	1
Total	**1**

(b) Explain, with reference to the Law of Conservation of Mass, why chemical equations need to be balanced. (2 marks)

Description	Marks
Matter cannot be created or destroyed (in a chemical reaction)	1
Balancing an equation ensures the same number and type of each atom are on both sides of the equation	1
Total	**2**

(c) Explain how this reaction conforms to the Law of Conservation of Energy, despite this release of heat. (3 marks)

Description	Marks
Energy cannot be created or destroyed (in a chemical reaction) **or** The total amount of energy in the 'system + surroundings' must be constant	1
The enthalpy of the products is lower than the enthalpy of the reactants **or** Energy input is required to break chemical bonds, and energy is released when new chemical bonds form	1
The enthalpy change represents the amount of enthalpy that has been converted to heat energy **or** The release of heat relates to the difference in energy associated with the bond breaking and making processes	1
Total	**3**

(d) Calculate the mass of biodiesel that would need to be combusted to produce one megajoule (1 MJ) of energy in the chemical reaction above. (3 marks)

Note: 1 MJ = 10^3 kJ.

Description	Marks
$n(C_{18}H_{32}O_2)$ = 1000 / 11380 = 0.08787 mol	1
$M(C_{18}H_{32}O_2)$ = 280.436 g mol^{-1}	1
$m(C_{18}H_{32}O_2)$ = 0.08787 x 280.436 = 24.6 g	1
Total	**3**

(e) State two (2) reasons why it is not always possible to use biodiesel in place of regular diesel. (2 marks)

Description	Marks
Any **two** of the following (or other relevant answer):	
• too expensive • not readily available • relatively new / unestablished technology • car engines are not equipped to use it • may cause damage to older engines • infrastructure to produce biodiesel not existing • shortage of appropriate raw materials	2
Total	**2**

Question 34 **(7 marks)**

(a) Write a balanced molecular, thermochemical equation representing this reaction. (4 marks)

Description	Marks
Equation: $Ba(OH)_2(aq) + 2\ NH_4Cl(s) + 26\ kJ \rightarrow 2\ H_2O(l) + 2\ NH_3(g) + BaCl_2(aq)$	
Correct reactants	1
Correct products	1
Correctly balanced	1
Correct enthalpy change	1
Total	**4**

(b) Explain, in terms of structure and bonding, why the ammonia produced in this reaction is a gas at room temperature. (3 marks)

Description	Marks
Ammonia is a covalent molecular substance (which exists as discrete molecules)	1
These molecules only exhibit weak intermolecular forces	1
Thus a small amount of heat is required to disrupt these forces, resulting in a low boiling point	1
Total	**3**

Question 35 **(7 marks)**

(a) Write the electron configuration of magnesium and phosphorus. (2 marks)

Description		Marks
Mg	2, 8, 2	1
P	2, 8, 5	1
	Total	**2**

(b) Write the electron configuration for the new species that form. (2 marks)

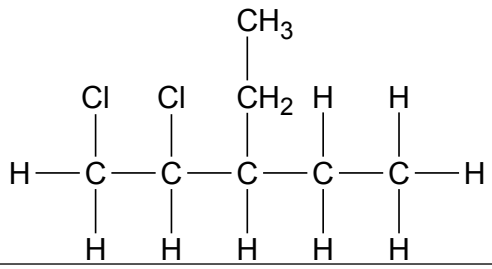
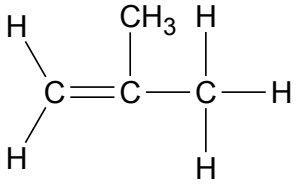
Description		Marks
Mg^{2+}	2, 8	1
P^{3-}	2, 8, 8	1
	Total	**2**

(c) Explain why each of these changes in electron configuration occur when magnesium and phosphorus react. (3 marks)

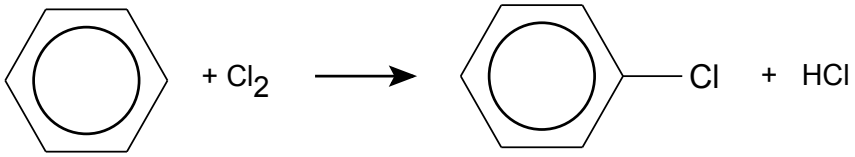
Description	Marks
Both elements react in order to achieve a full octet which is a stable electron configuration	1
Magnesium has 2 valence electrons and therefore will lose 2 electrons to develop a +2 change	1
Phosphorus has 5 valence electrons and therefore will gain 3 electrons to develop a -3 charge	1
Total	**3**

Question 36 **(8 marks)**

(a) Complete the table below by writing the IUPAC name or drawing a structural diagram for each organic substance. (6 marks)

Description		Marks
IUPAC name	(cis-)1-bromobut-2-ene	2
Structural diagram		2
Structural diagram		2
	Total	**6**
Note: one mark may be allocated for minor error		

(b) Write a chemical equation for the catalysed reaction that occurs between benzene and chlorine gas. Use structural formulae for all organic substances. (2 marks)

Description	Marks
Equation: 	
Correct reactants	1
Correct products	1
Total	**2**

Section Three: Extended answer **40% (88 marks)**

Question 37 **(15 marks)**

(a) Classify this reaction as an endothermic or exothermic reaction, and state whether the value of H is positive or negative. (2 marks)

Description		Marks
The reaction is	exothermic	1
The value of H is	negative	1
	Total	**2**

(b) Compare the energy associated with the bond breaking and bond making processes involved in this reaction. (2 marks)

Description	Marks
The energy required to break the bonds is less	1
than the energy released when new bonds form	1
Total	**2**

(c) Calculate the amount of energy released by the explosion, and state this value in terms of 'tonnes of TNT equivalent'. (5 marks)

Description		Marks
$m(NH_4NO_3)$	$= 2750 \times 10^6$ $= 2.750 \times 10^9$ g	1
$n(NH_4NO_3)$	$= 2.750 \times 10^9 / 80.052$ $= 3.4353 \times 10^7$ mol	1
energy	$= (3.4353 \times 10^7) \times 36$ $= 1.2367 \times 10^9$ kJ	1
	= 1236.7 GJ	1
TNT equiv.	= 1236.7 / 4.184 = 296	1
	Total	**5**

(d) Calculate how many atoms of nitrogen would have been delivered per metre squared of soil. State your answer to the appropriate number of significant figures. (6 marks)

Description	Marks
$m(NH_4NO_3)$ = (40/100) x 1.375 x 10^6 = 5.50 x 10^5 g	1
$n(NH_4NO_3)$ = 5.50 x 10^5 / 80.052 = 6870.534 mol	1
n(N) = 2 x 6870.534 = 13741 mol	1
N(N) = 6.022 x 10^{23} x 13741 = 8.27 x 10^{27} atoms	1
N(N per m^2)= 8.27 x 10^{27} / 25000 = 3.30995 x 10^{23} atoms	1
= 3.31 x 10^{23} atoms (3 SF)	1
Total	**6**

Question 38 **(18 marks)**

(a) Define ‘first ionisation energy’. (2 marks)

Description	Marks
The energy required to remove one mole of valence electrons	1
from one mole of the gaseous element.	1
Total	**2**

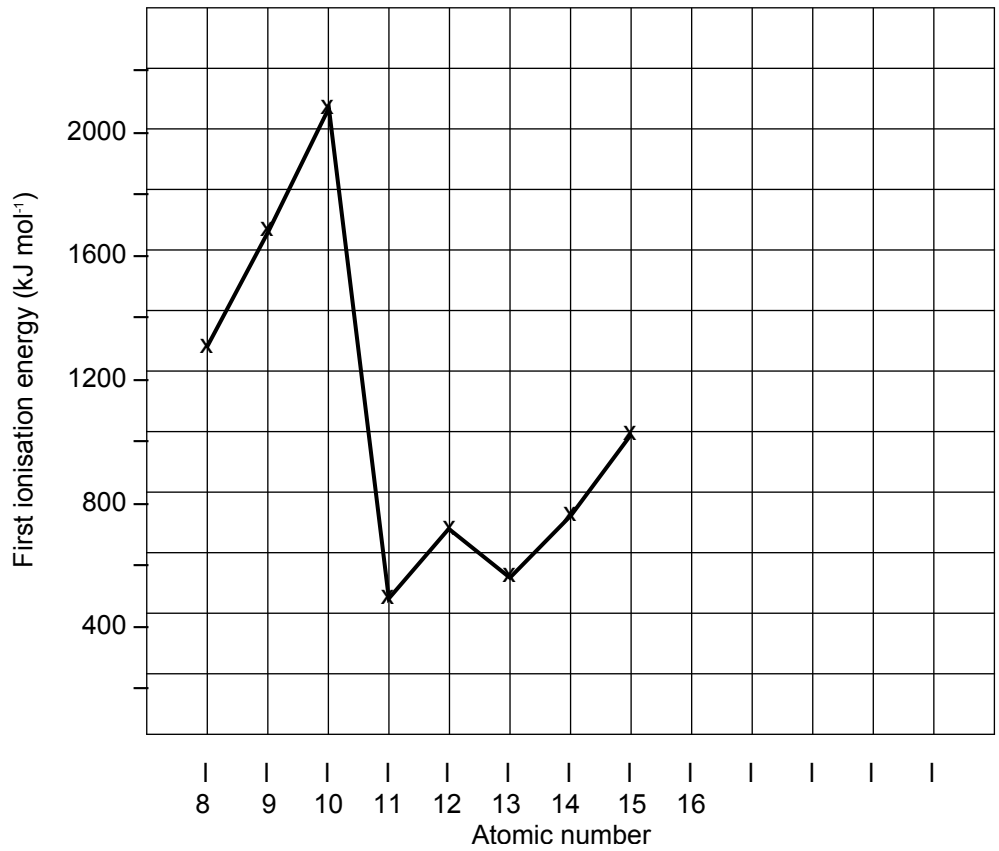
(b) State whether the data obtained by the students would be classified as ‘primary’ or ‘secondary’ data. Justify your answer. (2 marks)

Description	Marks
Secondary	1
The students did not measure and collect the data directly themselves	1
Total	**2**

(c) Graph the data collected by the students, using the grid below. (4 marks)

Description	Marks
x-axis label and scale	1
y-axis label and scale	1
Correct data points	1
Line or column graph used	1
Total	**4**

Example of a four mark response



(d) Explain the increasing trend in first ionisation energy for the elements with atomic number 13-15. (3 marks)

Description	Marks
There is an increasing positive charge / number of protons in the nucleus	1
Therefore a stronger force of attraction on the valence electrons	1
Thus a larger amount of energy is required to remove the valence electrons	1
Total	**3**

(e) Explain why there is such a large difference in the first ionisation energy of neon and sodium. (2 marks)

Description	Marks
The valence electrons of neon are in shell 2, whereas the valence electron of sodium is in shell 3 (and therefore further from the nucleus)	1
The valence electron of sodium therefore experiences a lesser force of attraction to the nucleus, thus less energy is required to remove it	1
Total	**2**

(f) Suggest an appropriate range, in which the first ionisation energy of the element with atomic number 16 would fall. Justify your answer. (3 marks)

Description	Marks
Within the range 1012 - 1314 kJ mol^{-1}	1
Must be higher than that of P, since they are in the same period	1
Must be lower than O, since they are in the same group	1
Total	**3**

(g) Which of the elements studied by the students would have (2 marks)

Description		Marks
(i) the highest electronegativity?	fluorine	1
(ii) the smallest atomic radius?	neon	1
Total		**2**

Question 39 **(19 marks)**

(a) Calculate the mass of chlorine gas that would be required to completely react with the rutile ore. (5 marks)

Description		Marks
$m(TiO_2)$	= (61.7/100) x 2420 = 1493.14 kg	1
$m(TiO_2)$	= 1493.14 x 10^3 = 1493140 g	1
$n(TiO_2)$	= 1493140 / 79.87 = 18695 mol	1
$n(Cl_2)$	= 2 x 18694.6 = 37389 mol	1
$m(Cl_2)$	= 37389 x 70.9 = 2.65 x 10^6 g	1
	Total	**5**

(b) Use the information provided in the table, to explain how the cooling process would allow separation of $TiCl_4$ to occur. (2 marks)

Description	Marks
The boiling point of $TiCl_4$ is much higher (136.4°) than that of CO_2 (-78.5°)	1
If the temperature is lowered (to below 136.4°), $TiCl_4$ will condense first (and thus can be collected and removed)	1
Total	**2**

(c) Use the information provided in the table, to suggest a temperature at which this reaction might be carried out. Justify your answer. (3 marks)

Description	Marks
Any value within the range 714 - 1412 °C	1
Since $MgCl_2$ is in the liquid/molten state	1
the temperature must be between the melting and boiling point of $MgCl_2$	1
Total	**3**

(d) Calculate the length of piping that could be manufactured from 2695 kg of $TiCl_4$. (5 marks)

Description		Marks
$n(TiCl_4)$	= (2695 x 10^3) / 189.67 = 14209 mol	1
n(Ti)	= 14209 mol	1
m(Ti)	= 14209 x 47.87 = 680180 g	1
	= 680.18 kg	1
length	= 680.18 / 5.43 = 125 metres	1
	Total	**5**

(e) State the property of metals which allows them to be shaped easily into pipes. Explain the basis of this property, in terms of structure and bonding. (4 marks)

Description	Marks
Malleability / ductility	1
Metallic bonding consists of a sea of delocalised electrons surrounding positive metal ions	1
This bonding is non-directional	1
Therefore if a force is applied, the metal can change shape without disrupting the bonding	1
Total	**4**

Question 40 **(18 marks)**

(a) Describe the difference between a 'saturated' and an 'unsaturated' organic compound, and provide an example of each from the table above. (3 marks)

Description	Marks
Saturated refers to all single carbon-carbon bonds	1
Unsaturated refers to one or more double or triple carbon-carbon bonds	1
One correct example of each:	
saturated – octane unsaturated – oct-1-ene **or** octa-1,3-diene **or** octa-1,3,5-triene	1
Total	**3**

(b) Complete the table above by calculating the average time taken for the remaining three test tubes. (3 marks)

Description		Marks
oct-1-ene average	6.06 s	1
octa-1,3-diene average	3.04 s	1
octa-1,3,5-triene average	2.04 s	1
Total		**3**

(c) Give two (2) reasons the students performed multiple trials. (2 marks)

Description	Marks
Reduces the effects of random error	1
Increases reliability of the data	1
Total	**2**

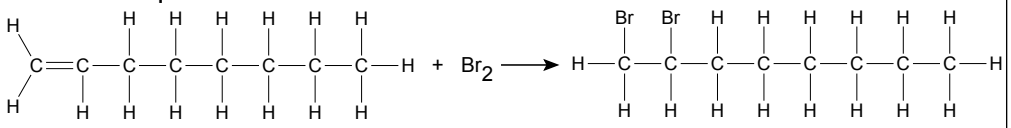
(d) Complete the table below, by listing the variables for this investigation. (3 marks)

Description		Marks
Independent variable	Number of double bonds in organic substance	1
Dependant variable	Time taken for red to fade to colourless	1
One (1) controlled variable	Any of the following (or other relevant): • mass of bromine • mass of organic compound • temperature of reactants • rate of stirring	1
Total		**3**

(e) Why is it important for the organic liquid to be present in excess? (1 mark)

Description	Marks
So the colour of the mixture can be observed to change from red to colourless (rather than remaining red, as would occur if the bromine was in excess)	1
Total	**1**

(f) Name the type of reaction that would have taken place in the test tube containing oct-1-ene. Write a chemical equation for this reaction, using structural formulae. (3 marks)

Description	Marks
Name of reaction type: addition	1
Chemical equation:  **or** $CH_2{=}CHCH_2CH_2CH_2CH_2CH_2CH_3+Br_2 \rightarrow CH_2BrCHBrCH_2CH_2CH_2CH_2CH_2CH_3$	2
Total	**3**
Note: one mark may be allocated for a minor error in the equation, such as a missing H atom or use of hept-1-ene	

(g) State the conditions that would be required for a reaction to take place, and name the type of reaction that would occur under these circumstances. (2 marks)

Description		Marks
Conditions required	UV light	1
Name of reaction type	substitution	1
Total		**2**

(h) Write a conclusion that the students could draw from the data collected in this investigation. Your conclusion should relate to your stated variables. (1 mark)

Description	Marks
Any relevant conclusion	1
Examples include: • The more double bonds in the organic substance, the less time taken for the reaction to complete. • The greater the degree of unsaturation, the faster the reaction rate.	
Total	**1**

Question 41 **(18 marks)**

(a) Define an isotope. (1 mark)

Description	Marks
Atoms of the same element with different numbers of neutrons	1
Total	**1**

(b) Complete the table below for both isotopes of oxygen. (2 marks)

Description				Marks
^{16}O	8	8	2, 6	1
^{18}O	8	10	2, 6	1
Total				**2**

(c) Compare and contrast the physical and chemical properties of isotopes. (2 marks)

Description	Marks
Physical properties are different	1
Chemical properties are the same	1
Total	**2**

(d) Calculate the relative molecular mass for a single molecule of water containing each oxygen isotope. Predict which type of water will undergo the processes of condensation and evaporation more readily. (4 marks)

Description		Marks
Water containing 'light' oxygen		
Relative molecular mass (Mr)	18.016	1
Which process will occur more readily?	evaporation	1
Water containing 'heavy' oxygen		
Relative molecular mass (Mr)	20.016	1
Which process will occur more readily?	condensation	1
Total		**4**

(e) State which fossil (A or B) is more likely to have come from an organism that lived during an ice age. Calculate the average relative atomic mass of the oxygen found in this 'ice age fossil'. (3 marks)

Description	Marks
Fossil B	1
Ar = (99.68 x 16 + 0.32 x 18) / 100	1
= 16.01	1
Total	**3**

(f) State the predominant type of bonding present in both $CaCO_3$ and SiO_2, and briefly describe the structure of each. (4 marks)

Description	Marks
$CaCO_3$ – ionic	1
It is composed of cations and anions which are held in fixed positions within a rigid 3D lattice	1
SiO_2 – covalent network	1
It consists of an extensive, interconnected 3D network of covalent bonds	1
Total	**4**

(g) Other than hardness and brittleness, state one other physical property that $CaCO_3$ and SiO_2 have in common, and one that distinguishes them. (2 marks)

Description	Marks
Any of the following:	
Common property: • Both have high melting / boiling points • Both crystalline • Both white in colour	1
Any of the following:	
Distinguishing property: • Only $CaCO_3$ conducts electricity when molten • Melting point of $CaCO_3$ would be lower than SiO_2	1
Total	**2**