ATAR CHEMISTRY
Unit 1/2
Semester 1 2016

SHENTON
C O L L E G E

Name: _____

Teacher (circle): **Lee**   **Saggers-Gray**   **Smith**

Time allowed for this paper
Reading time before commencing work: ten minutes
Working time for paper: two hours

Materials required/recommended for this paper
To *be provided by the supervisor*
This Question/Answer Booklet
Multiple-choice Answer Sheet
Chemistry Data Sheet

To *be provided by the candidate*
Standard items: pens, pencils, eraser, correction fluid/tape, ruler, and highlighters

Special items: non-programmable calculators satisfying the conditions set out by the SCSA for this course

Important note to candidates
No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Section 1	Section 2	Section 3	Total	Percentage
				%
/25	**/63**	**/32**	**/120**	

Structure of this paper

Section	Number of questions	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Multiple-choice	25	30	25	20
Section Two: Short answer	10	55	63	53
Section Three: Extended answer	4	35	32	27
		TOTAL	**120**	**100**

Instructions to candidates

1.   Answer the questions according to the following instructions.

   Section One: Answer all questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, do not erase or use correction fluid, and shade your new answer. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

   Sections Two and Three: Write your answers in this Question/Answer Booklet.

2.   When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

3.   You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

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

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square, do not erase or use correction fluid, and shade your new answer. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 25 minutes.

1. Which of the following pairs of elements forms a compound by sharing electrons?
    a. Sulfur and lead
    b. Magnesium and oxygen
    c. Nitrogen and bromine
    d. Potassium and iodine

2. Which one of the following species contains a different number of electrons from the others?
    a. O_2
    b. C_2H_4
    c. CN^-
    d. HNO

3. Which of the following reactions is an exothermic reaction?
    a. $H_2\,(g) \rightarrow 2H\,(g)$
    b. $I_2\,(g) \rightarrow I_2\,(s)$
    c. $CO_2\,(g) \rightarrow C\,(s) + O_2\,(g)$
    d. $NaCl\,(s) \rightarrow NaCl\,(aq)$

4. The formula of an organic compound is $C_4H_5N_2O$. What is the percentage of carbon in the compound?
    a. 4%
    b. 33.3%
    c. 40%
    d. 49.5%

5. Which one of the following has a noble gas electron configuration?
    a. H^+
    b. Cl
    c. K
    d. H^-

6. Which of the following will NOT conduct electricity?
    a. A crystal of sodium chloride
    b. Molten silver nitrate
    c. An aqueous solution of ammonium chloride
    d. Magnesium ribbon

7. The next question refers to the energy profile diagram for the reaction

$$C_{(s)} \quad + \quad O_{2(g)} \quad \rightarrow \quad CO_{2(g)}$$
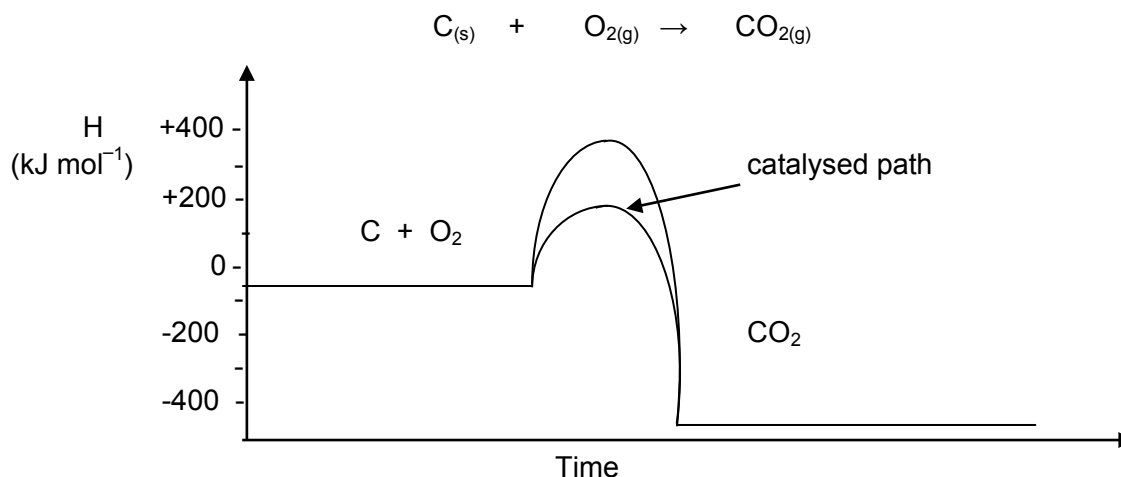
For the **reverse reaction**, <u>using a catalyst</u>, the activation energy and ΔH **respectively** are approximately:

a. 790 kJ   and   400 kJ
b. 200 kJ   and   – 390 kJ
c. 590 kJ   and   – 200 kJ
d. 590 kJ   and   390 kJ

8. Which of the following statements about activation energy is **NOT TRUE**?
   a. It is the minimum energy that is required by colliding reactants for a chemical reaction to take place.
   b. It can be considered to be an energy barrier or resistance that has to be overcome in order to produce a reaction.
   c. Endothermic reactions have higher activation energies than exothermic reactions.
   d. Chemical reactions with a smaller activation energy tend to progress at a faster rate than those with higher activation energies.

9. Consider the reaction:

$$N_2\,(g) \ + \ 3H_2\,(g) \ \rightarrow \ \ 2NH_3\,(g)$$

Increasing the pressure of this system causes the rate of reaction to increase.
Which of the following statements best explains this observation?

   a. The average kinetic energy of the reactant molecules increases.
   b. The number of reactant molecules with energies greater than the activation energy increases.
   c. The volume increases, there is more of the reacting gases and so the rate of reaction increases.
   d. The particles will collide more often.

10. The relative atomic mass of Bromine is 79.9. Which of the following provides the best explanation for this fact?
   a. Bromine consists of unequal amounts of the ^{78}Br and ^{79}Br isotopes.
   b. All Bromine atoms have a relative mass 79.9.
   c. The weighted average relative mass of all the isotopes of Br is 79.9.
   d. Bromine must contain equal amounts of two isotopes, ^{79}Br and ^{81}Br.

11. Consider the following pairs of elements:

        I   Hydrogen and oxygen
        II   Nitrogen and nitrogen
        III   Calcium and chlorine
        IV   Zinc and oxygen
        V   Carbon and hydrogen

The pairs that can form covalent bonds are:

a. I, II and V
b. I and II
c. I, II and IV
d. III and V

12. How many lone pairs (non-bonding) of electrons would be found in a molecule of PH_3?
    a. 1
    b. 2
    c. 3
    d. 4

13. Which of these statements concerning ionic compounds is FALSE?
    a. They have a high melting point.
    b. They conduct electricity when dissolved in water.
    c. They always have an equal number of positive and negative ions.
    d. They are brittle.

14. The percentage of water of crystallisation in hydrated magnesium sufate ($MgSO_4 \cdot 7H_2O$) is closest to:
    a. 51%
    b. 58%
    c. 60%
    d. 71%

15. How many moles of hydrogen atoms are found in 3.5 mol of saccharin ($C_7H_5NO_3S$)?
    a. 59.5 mol
    b. 3.5 mol
    c. 17.6 mol
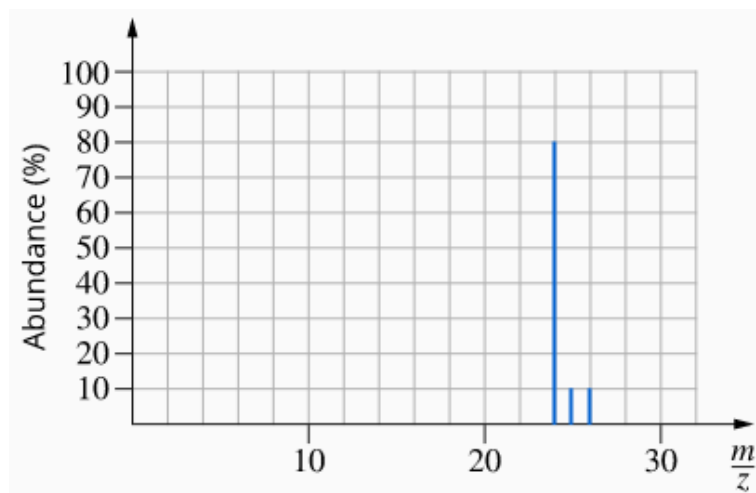   d. 17.5 mol

16. A metal has a sulfide X_2S_3. The correct formula for its bromide is:
    a. XBr_2
    b. XBr_3
    c. XBr
    d. X_3Br_2

17. How many oxygen atoms are found in 0.250 g of glucose ($C_6H_{12}O_6$)? (180.156)
    a. 45
    b. 1.39×10^{-3}
    c. 8.36×10^{20}
    d. 5.01×10^{21}

18. The mass spectrum of magnesium is found below.

Which of the following statements are correct?

I   There are 3 stable isotopes of the element
II   The peak at 24 has one less proton than the peak at 25
III All peaks come from atoms with the same number of neutrons
IV   The peak at 24 comes from the most abundant isotope of the element

a. I, II, III and IV
b. I, III and IV
c. III only
d. I and IV

19. The following equation is unbalanced. If two moles of sulfuric acid (H_2SO_4) are completely consumed, approximately how many moles of aluminium sulfate would be produced?

$$H_2SO_4 \text{ (aq)} + Al(OH)_3 \text{ (s)} \rightarrow Al_2(SO_4)_3 \text{ (aq)} + H_2O \text{ (l)}$$

a. 1.00 mol
b. 0.67 mol
c. 0.33 mol
d. 0.17 mol

20. Which of the following correctly identifies the observations of products and reactants that would be made in the following reaction shown by the equation below?

$$HNO_3 \text{ (aq)} + Cu \text{ (s)} \rightarrow Cu(NO_3)_2 \text{ (aq)} + NO_2 \text{ (g)} + 2H_2O \text{ (l)}$$

a. A silver solid is added to colourless solution to produce a colourless solution and a brown, odourless gas
b. A salmon-pink solid is added to a colourless solution to produce a blue solution and a colourless, odourless gas
c. A salmon-pink solid is added to a colourless solution to produce a salmon-pink solution and a colourless, odourless gas
d. A salmon-pink solid is added to a colourless solution to produce a blue solution and brown, odourless gas.

21. Which of the following properties have a decreasing trend across Period 3 of the Periodic Table?

      I.   Atomic number
     II.   Atomic radius
    III.   Electronegativity
    IV.   First ionization energy

    a. III and IV
    b. I, III and IV
    c. II only
    d. I, II, and III

22. Which of the following separation techniques would be used to obtain salt from seawater?
    a. Filtration
    b. Crystallisation
   c. Gravity separation
    d. Distallation

23. Which of the following would have the highest melting point in its elemental form?
    a. Sodium
    b. Aluminium
    c. Silicon
    d. Sulfur

24. The high melting point of silicon dioxide can best be explained by the presence of:
    a. Strong covalent bonds
    b. Strong metallic bonds
    c. Strong intermolecular forces
    d. Strong ionic bonds

25. A composition of a crushed rock sample was investigated using atomic emission spectroscopy. After dissolving in acid the rock sample solution was heated to produce an emission spectrum. Shown below is this emission spectrum, along with those of five metals. Based on this spectral analysis it can be concluded that the rock sample contains:
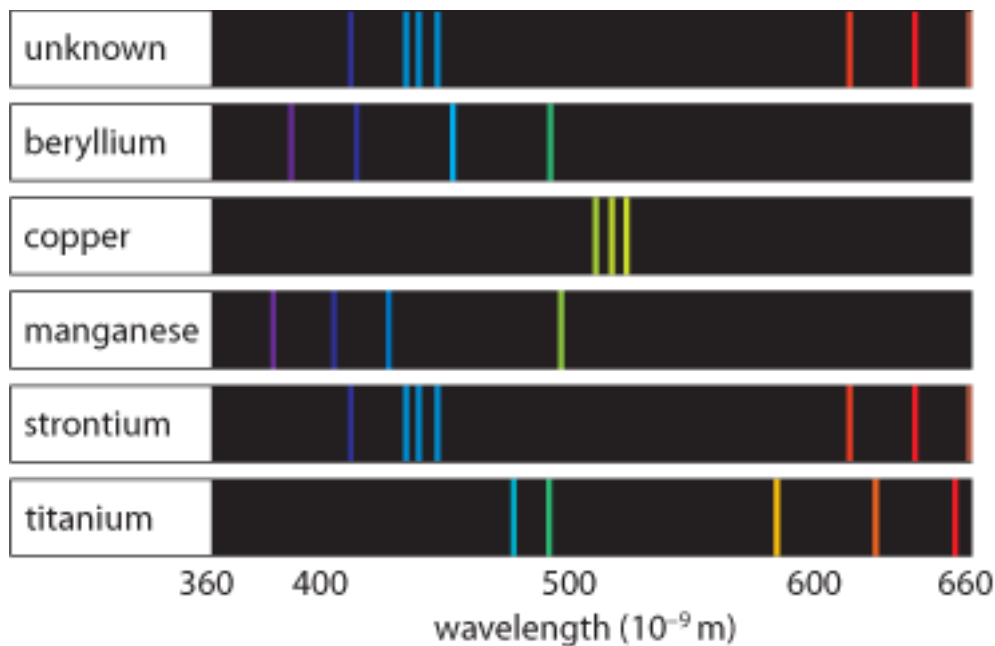
a. All five of the metals
b. Strontium, but none of the other four metals
c. None of the five metals
d. Strontium and manganese, but none of the other three metals.

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Section Two: Short answer 53% (63 Marks)

This section has **10** questions - answer **all** questions in the spaces provided.
Suggested working time: 55 minutes.

Question 26 (3 marks)

The catalytic converter in a car takes in the undesirable gases produced by the combustion of petrol, such as carbon monoxide and various nitrogen oxides, and converts them into less harmful gases such as carbon dioxide, nitrogen gas and water. The less harmful gases are released into the atmosphere as we drive.

NO_x
hydrocarbons   catalytic N_2
CO   converter H_2O
                                          CO_2
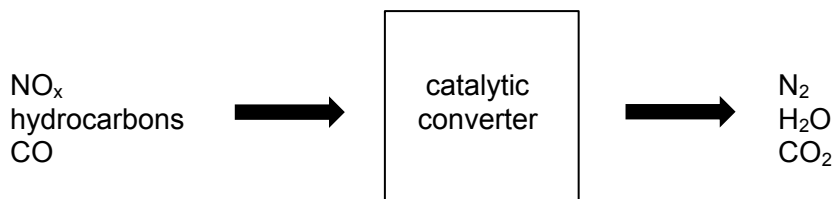
Metals such as platinum, palladium and rhodium are used as the catalyst in a catalytic converter.

Explain what a catalyst is and **describe** its effect on the rate of a reaction.

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_____

Question 27 (3 marks)

Calculate the relative atomic mass of a sample of rubidium, given that a mass spectrometer shows that it consists of 72.2% of ^{85}Rb and 27.8% of ^{87}Rb. Show all your working and give your answer to the appropriate number of significant figures.

Question 28 (8 marks)

Draw electron dot diagrams to represent the following substances.

$(NH_4)_3P$

$PO_4{}^{3-}$

SO_3

N_2

Question 29 **(9 marks)**

Hydrazine (N_2H_4) is a toxic, unstable substance, which is sometimes used in rocket fuels. When hydrazine is passed over a catalyst such as molybdenum nitride on alumina, it decomposes very quickly according to the following equation;

$$N_2H_4 \ (l) \ \rightarrow \ N_2 \ (g) \ + \ 2 \ H_2 \ (g)$$
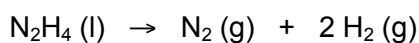
The activation energy for this reaction is 295 kJ mol^{-1} and the activation energy for the reverse reaction is 1335 kJ mol^{-1}.

(a)   Calculate the enthalpy change (ΔH).   (1 mark)

_____

(b)   Sketch a labelled potential energy diagram for the uncatalysed decomposition of hydrazine. Label the reactants and the products of the reaction, activation energy, reverse activation energy and enthalpy change.   (4 marks)

Progress of reaction
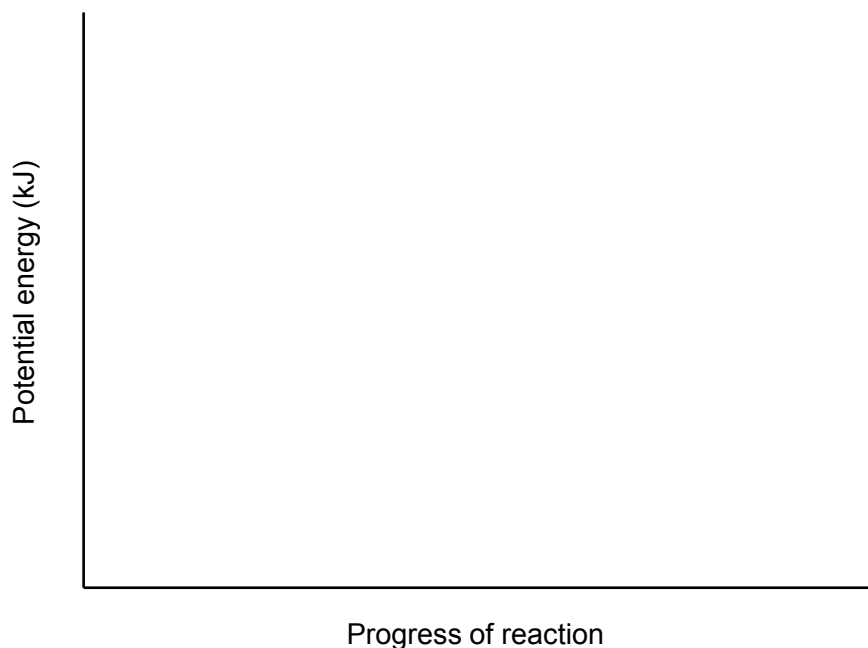
(c)   If the molybdenum nitride on alumina catalyst had been used, show the effect this would have on the potential energy diagram above.   (1 mark)

(d)   What effect (higher, lower, unchanged) would the addition of a catalyst have on the **value** of each of the following?   (3 marks)

    (i)   Activation energy   _____

    (ii)   Reverse activation energy   _____

    (iii)   Enthalpy change   _____

Question 30 (5 marks)

Consider the following substances:

Bronze   Graphite   Silver   Ammonia   Pentane (C_2H_5)   Mercury   Potassium ethanoate

Magnesium sulfate   Silicon dioxide   Ammonium nitrate   Carbon tetrafluoride

Determine the bonding present in each substance and place them in the correct column of the table:

Ionic	Covalent molecular	Covalent Network	Metallic

Question 31 (4 marks)

Atomic absorption spectroscopy is highly specific. This means it will only detect the presence (and concentration) of a single element within a sample. Explain **why** and **how** this analytical technique is so specific.

Question 32 **(6 marks)**

a)   Write the formulae for the following compounds: (3 marks)

      A: barium chloride dihydrate   _____

      B: calcium nitride   _____

      C: diphosphorous pentoxide   _____

      D: sulfur hexafluoride   _____

      E: ammonium phosphate   _____

      F: carbon disulfide   _____

b)   Which of compounds A and E has the higher molar mass? Show all working to support your
       answer   (3 marks)

Question 33 **(3 marks)**

Explain the trend seen in first ionization energy as you move from left to right across a period.

_____

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Question 34 **(16 marks)**

A student carried out an experiment to measure the rate of the reaction between calcium carbonate and hydrochloric acid at 20°C.

$$CaCO_3 \text{ (s)} + 2HCl \text{ (aq)} \rightarrow CaCl_2 \text{ (aq)} + CO_2 \text{ (g)} + H_2O \text{ (l)}$$
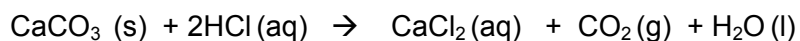
She used the apparatus shown below. Her results are show in the table below.

Time (min)	Mass of Carbon Dioxide given off (g)
0	0
2	1.5
4	2.5
6	3.1
8	3.4
10	3.6
16	3.8
18	3.8

a)   Plot a graph of the results   (5 marks)

b)   What does the shape of the graph tell you about this reaction? Explain why the rate changes
      with time.   (4 marks)

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c)   On the same axes sketch a graph to indicate the predicted results if the reaction was carried out
      at $40^{o}C$. Mark your answer clearly.   (2 marks)

d)   Explain why data collected at $40^{o}C$ will be different from the data set at $20^{o}C$.   (4 marks)

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e)   Suggest another way, apart from temperature, in which this speed of this reaction could be
      increased.   (1 mark)

_____

Question 35 (6 marks)

Three different tests were carried out on three solids. The observations taken are in the table below.

Tests	OBSERVATIONS		
	Substance 1	**Substance 2**	**Substance 3**
Heated gently	No visible change	Melted easily	No visible change
Electrical conducutivity	Good conductor in both solid and liquid states	Non-conductor in both solid and liquid states	Non-conductor in solid state Good conductor in liquid state
Hit with a hammer	Flattened	Flattened	Shattered

a)   What type of bonding is exhibited in: (3 marks)

(i) Substance 1 _____

(ii) Substance 2 _____

(iii) Substance 3 _____

b)   Use your understanding of structure and bonding to **explain** why Substance 3 shatters when hit with a hammer. (3 marks)

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Section Three: Extended answer   27% (32 Marks)
This section contains **four (4)** questions. You must answer all questions. Write your answers in the spaces provided.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

Suggested working time: 35 minutes.

Question 36   **(11 marks)**

The police are trying to identify a white powder that they suspect might be cocaine ($C_{17}H_{21}NO_4$) or heroin ($C_{21}H_{23}NO_5$). Analysis of the sample shows that it contains approximately 68.27% carbon by mass.

a)   Calculate the **% carbon by mass** in each of the two white powders and hence **identify** the white powder.   (5 marks)

b)   In another case a suspect is arrested in possession of 2.46g of heroin.

      i)   Calculate the number of moles of heroin in the sample.   (2 marks)

ii)   Calculate the number of molecules of heroin in the sample.   (2 marks)

iii)   Calculate the number of carbon atoms in the sample.   (2 marks)

Question 37   **(5 marks)**

Nitrogen, phosphorus and potassium are the three major elements needed for healthy plant growth. Urea $(NH_2)_2CO$ is an important nitrogen based fertiliser. It can be produced by the direct reaction of ammonia with carbon dioxide at a moderate temperature and a high pressure.

$2NH_{3\ (g)}$ + $CO_{2(g)}$ $\longrightarrow$ $(NH_2)_2CO_{(s)}$ + $H_2O_{(g)}$
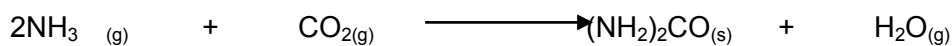
What mass of urea can be formed by the complete reaction of 10.0 kg of ammonia and excess carbon dioxide?

Question 38 (7 marks)

The reaction of granulated zinc with hydrochloric acid is a standard method of preparing hydrogen gas in the laboratory. **Describe three** ways to increase the rate of formation of hydrogen and **explain why** in terms of the collision theory.

Question 39 (9 marks)

The melting points and boiling points of three substances listed in the table below are noticeably different. **Describe the bonding** between atoms/molecules in these substances and **explain** how they can be used to justify the wide range of these values.

	Melting Point (^oC)	Boiling Point (^oC)
O_2	-219	-183
KCℓ	770	1437
SiO_2	1610	2230

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END OF EXAM