

Chemistry
Standard level
Paper 2

Wednesday 16 May 2018 (afternoon)

Candidate session number

1 hour 15 minutes

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Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.



Answer **all** questions. Answers must be written within the answer boxes provided.

1. Urea, $(\text{H}_2\text{N})_2\text{CO}$, is excreted by mammals and can be used as a fertilizer.

(a) (i) Calculate the percentage by mass of nitrogen in urea to two decimal places using section 6 of the data booklet. [2]

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(ii) Suggest how the percentage of nitrogen affects the cost of transport of fertilizers giving a reason. [1]

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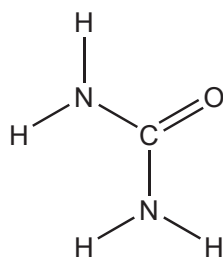
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(Question 1 continued)

- (b) The structural formula of urea is shown.

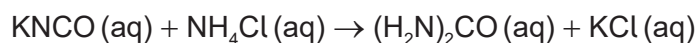


Predict the electron domain and molecular geometries at the nitrogen and carbon atoms, applying the VSEPR theory.

	Electron domain geometry	Molecular geometry
Nitrogen
Carbon	trigonal planar

[3]

- (c) Urea can be made by reacting potassium cyanate,
- KNCO
- , with ammonium chloride,
- NH_4Cl
- .



Determine the maximum mass of urea that could be formed from 50.0 cm^3 of $0.100 \text{ mol dm}^{-3}$ potassium cyanate solution.

[2]

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(Question 1 continued)

- (d) Urea can also be made by the direct combination of ammonia and carbon dioxide gases.



Predict, with a reason, the effect on the equilibrium constant, K_c , when the temperature is increased.

[1]

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- (e) (i) Suggest one reason why urea is a solid and ammonia a gas at room temperature.

[1]

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- (ii) Sketch **two** different hydrogen bonding interactions between ammonia and water.

[2]

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(Question 1 continued)

- (f) The combustion of urea produces water, carbon dioxide and nitrogen.

Formulate a balanced equation for the reaction.

[2]

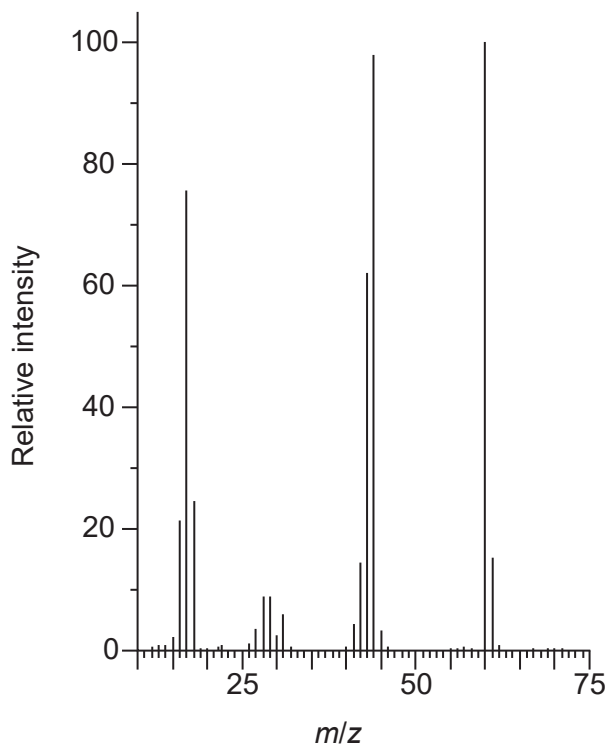
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(Question 1 continued)

(g) The mass spectrum of urea is shown below.



[Source: NIST Mass Spec Data Center, S.E. Stein, director, "Mass Spectra" in *NIST Chemistry WebBook*, NIST Standard Reference Database Number 69, Eds. P.J. Linstrom and W.G. Mallard, National Institute of Standards and Technology, Gaithersburg MD, 20899, doi:10.18434/T4D303, (retrieved May 31, 2018).]

Identify the species responsible for the peaks at $m/z = 60$ and 44 .

[2]

60:

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44:

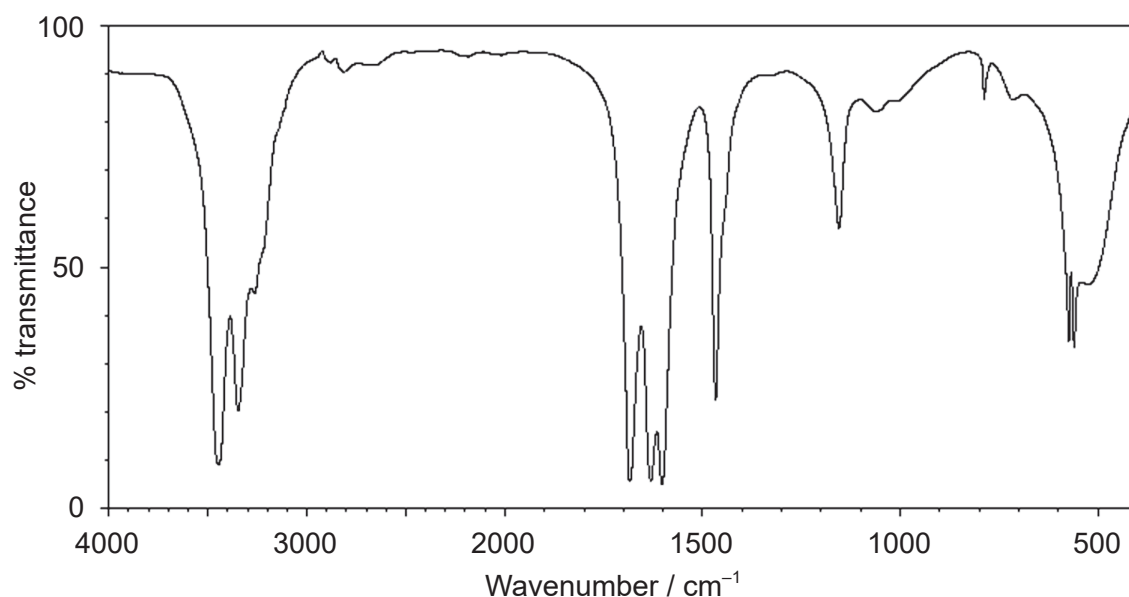
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(Question 1 continued)

(h) The IR spectrum of urea is shown below.



[Source: SDBS, National Institute of Advanced Industrial Science and Technology]

Identify the bonds causing the absorptions at 3450 cm^{-1} and 1700 cm^{-1} using section 26 of the data booklet.

[2]

3450 cm^{-1} :

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1700 cm^{-1} :

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(i) Predict the number of signals in the ^1H NMR spectrum of urea.

[1]

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2. Calcium carbide, CaC_2 , is an ionic solid.

(a) Describe the nature of ionic bonding.

[1]

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(b) State the electron configuration of the Ca^{2+} ion.

[1]

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(c) When calcium compounds are introduced into a gas flame a red colour is seen; sodium compounds give a yellow flame. Outline the source of the colours and why they are different.

[2]

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(d) (i) Suggest **two** reasons why solid calcium has a greater density than solid potassium.

[2]

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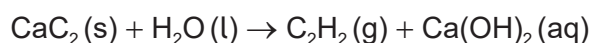


(Question 2 continued)

- (ii) Outline why solid calcium is a good conductor of electricity. [1]

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- (e) Calcium carbide reacts with water to form ethyne and calcium hydroxide.



- Estimate the pH of the resultant solution. [1]

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3. This question is about ethene, C₂H₄, and ethyne, C₂H₂.

- (a) (i) Ethyne, like ethene, undergoes hydrogenation to form ethane. State the conditions required. [2]

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- (ii) Outline the formation of polyethene from ethene by drawing three repeating units of the polymer. [1]

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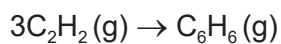


(Question 3 continued)

- (b) (i) Under certain conditions, ethyne can be converted to benzene.

Determine the standard enthalpy change, ΔH^\ominus , for the reaction stated, using section 11 of the data booklet.

[2]



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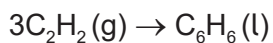
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- (ii) Determine the standard enthalpy change, ΔH^\ominus , for the following similar reaction, using ΔH_f values in section 12 of the data booklet.

[2]



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- (iii) Explain, giving two reasons, the difference in the values for (b)(i) and (ii). If you did not obtain answers, use -475 kJ for (i) and -600 kJ for (ii).

[2]

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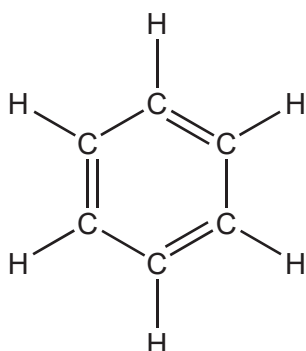
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(Question 3 continued)

(c) One possible Lewis structure for benzene is shown.



State one piece of physical evidence that this structure is **incorrect**.

[1]

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(d) State the characteristic reaction mechanism of benzene.

[1]

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4. Calcium carbonate reacts with hydrochloric acid.



(a) Outline **two** ways in which the progress of the reaction can be monitored. No practical details are required.

[2]

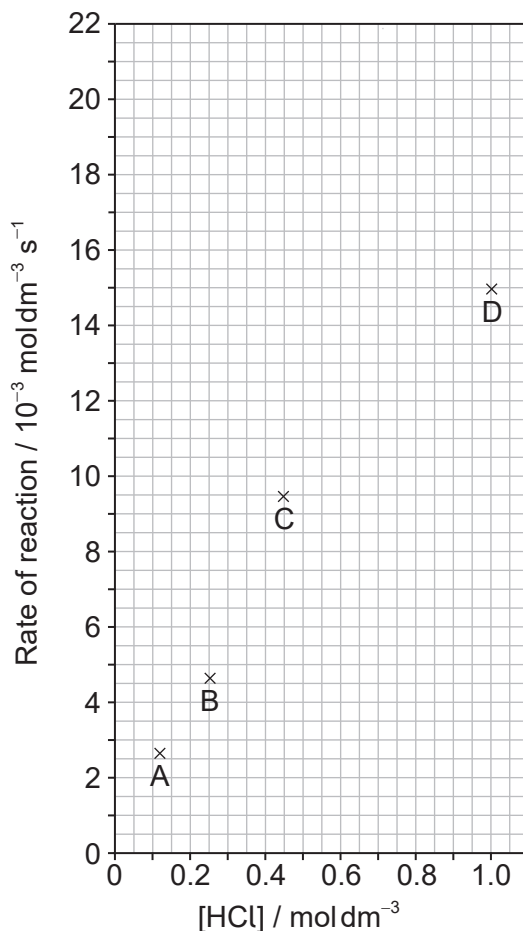
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(Question 4 continued)

- (b) The results of a series of experiments in which the concentration of HCl was varied are shown below.



- (i) Suggest why point D is so far out of line assuming human error is not the cause. [1]

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- (ii) Suggest the relationship that points A, B and C show between the concentration of the acid and the rate of reaction. [1]

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5. Limescale, CaCO_3 (s), can be removed from water kettles by using vinegar, a dilute solution of ethanoic acid, CH_3COOH (aq).

(a) Predict, giving a reason, a difference between the reactions of the same concentrations of hydrochloric acid and ethanoic acid with samples of calcium carbonate. [2]

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(b) Dissolved carbon dioxide causes unpolluted rain to have a pH of approximately 5, but other dissolved gases can result in a much lower pH. State one environmental effect of acid rain. [1]

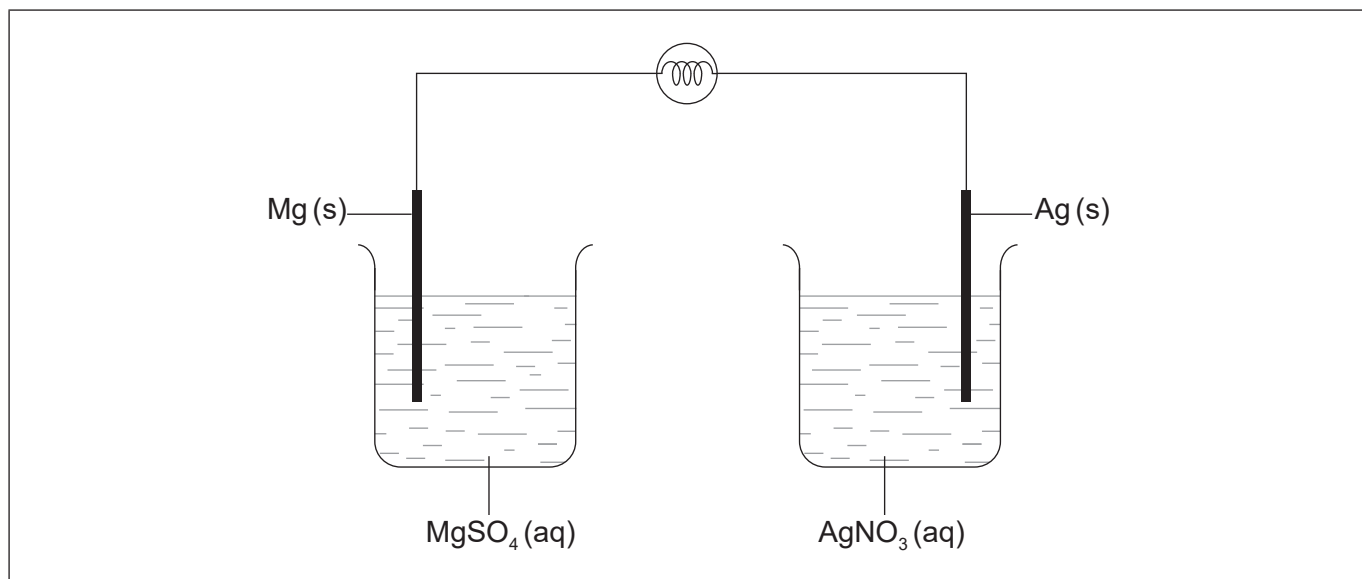
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6. The diagram shows an incomplete voltaic cell with a light bulb in the circuit.



(a) Identify the missing component of the cell and its function. [2]

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(b) Deduce the half-equations for the reaction at each electrode when current flows. [2]

Positive electrode (cathode):
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Negative electrode (anode):
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(c) Annotate the diagram with the location and direction of electron movement when current flows. [1]



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