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# Tasmanian Certificate of Education

# CHEMISTRY

## Senior Secondary 5C

*Subject Code: CHM5C*

**External Assessment**

# 2006

## Part 1

**Time: approximately 45 minutes**

On the basis of your performance in this examination, the examiners will provide a result on the following criteria taken from the syllabus statement:

**Criterion 4** Develop and evaluate experiments.

**Criterion 7** Demonstrate an understanding of the fundamental principles and theories of electrochemistry.

| Criterion | Mark |
|---|---|
| 7 | /32 |
| 4 | /8 |

Pages: 11
Questions: 5

## CANDIDATE INSTRUCTIONS

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**NOTE:** 1 litre (L) = 1000 millilitres (mL) = 1 $dm^3$ = 1000 $cm^3$.

The last question in each part is used in the assessment of Criterion 4.

**Question 1**

**For Marker Use Only**

*This question assesses Criterion 7.*

The element bromine ($Br_2$) is a liquid under normal laboratory conditions, and is often difficult to handle in the laboratory because it vaporises rapidly, and is quite poisonous. This problem can sometimes be avoided by making aqueous solutions of bromine by the reaction of a solution containing bromide ions ($Br^-$) with a solution of bromate ions ($BrO_3^-$) to which hydrogen ions ($H^+$) have been added. The only products of the reaction are bromine and water.

(a) Write the oxidation numbers of bromine in: (2 marks)

(i) $Br_2$ .....

(ii) $BrO_3^-$ .....

(b) Write separate balanced half-equations for the oxidation of the bromide ions and the reduction of the bromate ions, and therefore write a balanced equation for the overall redox reaction producing bromine and water. (4 marks)

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**For Marker Use Only**

**Question 2**

*This question assesses Criterion 7.*

An electrochemical cell is constructed by connecting the following two half-cells:

- a 1.00 $molL^{-1}$ solution of acidified dichromate ions (see Information Sheet) with an inert graphite electrode (graphite is an electrical conductor); and
- a 1.00 $molL^{-1}$ solution of $Fe^{+2}$ ions, also with a graphite electrode.

(a) In the space below draw a diagram of the electrochemical cell, indicating:

- which electrode is the cathode and which is the anode;
- the equations for the half reactions which occur at the electrodes;
- the direction of the electron flow in the external circuit;
- the direction in which the cations and anions flow between the two half-cells; and
- the shorthand description of the cell.

(6 marks)

**Question 2 continues oppostite.**

**Question 2 (continued)**

**For Marker Use Only**

(b) What is the maximum voltage you would expect the cell to produce under Standard Laboratory Conditions? Show your calculation. (2 marks)

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(c) Which half-cell would you expect to be the main cause of voltage loss over time, and eventually cause the cell to 'go flat'? Explain your answer. (3 marks)

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(d) How would you expect the operation of the cell to change if the graphite electrode in the $Fe^{+2}$ half-cell was replaced by an electrode of iron metal? Explain your conclusion. (3 marks)

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**For Marker Use Only**

**Question 3**

*This question assesses Criterion 7.*

Sea water contains significant quantities of sodium ions as well as chloride and bromide ions. After concentrating the sea water by evaporation, the resulting solution is electrolysed using inert graphite electrodes.

Predict the likely products at the anode and cathode and explain your conclusions.

(4 marks)

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**Question 4**

*This question assesses Criterion 7.*

One of the earliest examples of marine corrosion occurred in the eighteenth century on the British Navy battleship H.M.S. Alarm. The vessel had its wooden hull covered by copper sheeting, which was fastened by iron nails. Not surprisingly the iron nails corroded rapidly and some copper sheeting fell off the hull.

(a) Explain, using the principles of electrochemistry, why the corrosion took place.

(4 marks)

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**Question 4 continues opposite**

**Question 4 (continued)**

**For Marker Use Only**

(b) Why do you think the iron nails corroded so rapidly? (2 marks)

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(c) How might the corrosion have been prevented? (2 marks)

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**For Marker Use Only**

**Question 5**

*This question assesses Criterion 4.*

(a) The presence of $Fe^{+3}$ ions in aqueous solution can be detected using a solution containing thiocyanate ions. A deep red colour is produced in the solution.

$Fe^{+2}$ ions can be detected by reaction with ferricyanide ions, producing a deep blue precipitate.

Before using these tests as positive evidence of the presence of the respective ions, what additional tests should be conducted if the tests are to be conclusive?

Explain your answer. (2 marks)

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(b) The order of strength of the halogens as oxidising agents is indicated in the following table, chlorine being the strongest.

$$\mathbf{Cl_2(aq) + 2e^- \rightarrow 2Cl^-(aq)}$$

$$\mathbf{Br_2(aq) + 2e^- \rightarrow 2Br^-(aq)}$$

$$\mathbf{I_2(aq) + 2e^- \rightarrow 2I^-(aq)}$$

Describe an experiment which would allow you to place the following half equation:

$$\mathbf{Fe^{+3}(aq) + e^- \rightarrow Fe^{+2}(aq)}$$

in the correct position in the above series.

The reagents available are solutions containing:

$Cl_2$, $Br_2$, $I_2$, $Cl^-$, $Br^-$, $I^-$, $Fe^{+3}$, and $Fe^{+2}$

and the 'spot test' reagents, potassium ferricyanide and potassium thiocyanate.

**Question 5 continues opposite.**

**Question 5 (continued)**

**For Marker Use Only**

Outline the procedure you will use to achieve this aim, showing your reasoning and what you would expect to observe. (4 marks)

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(c) Given the method you have chosen in Part (b), briefly describe an additional experiment, using the reagents listed, which would help you to confirm your conclusion. (2 marks)

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# Tasmanian Certificate of Education

# CHEMISTRY

## Senior Secondary 5C

*Subject Code: CHM5C*

**External Assessment**

# 2006

## Part 2

**Time: approximately 45 minutes**

On the basis of your performance in this examination, the examiners will provide a result on the following criteria taken from the syllabus statement:

**Criterion 4** Develop and evaluate experiments.

**Criterion 8** Demonstrate knowledge and understanding of the principles and theories of thermochemistry, kinetics and equilibrium.

| Criterion | Mark |
|---|---|
| 8 | /32 |
| 4 | /8 |

Pages: 11
Questions: 7

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For Marker Use Only

**Question 6**

*This question assesses Criterion 8.*

The rates of most chemical reactions decrease over time. For example, the reaction between hydrogen ions and carbonate ions may be quite rapid when they are first mixed (producing carbon dioxide gas), but it is observed that the measured rate of gas evolution reduces as the reaction proceeds. Explain why this happens. (2 marks)

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**Question 7**

*This question assesses Criterion 8.*

Some ***exothermic*** reactions must be carried out with great care since their reaction rates can accelerate so quickly they become dangerous. Explain, at the molecular level, what may cause this effect. (2 marks)

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**For Marker Use Only**

**Question 8**

*This question assesses Criterion 8.*

The **bond energy** of a chemical bond is the energy required to overcome the forces operating between atoms which hold them together.

Some bond energies are listed in the table below:

| Bond Type | Bond Energy ($kJmol^{-1}$) |
|---|---|
| C – H | 435 |
| C – C | 347 |
| O = O | 498 |
| C = O | 805 |
| O – H | 464 |

The reaction for the combustion of propane (the gas used in most Bunsen burners) is given by the equation:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$

Use the information in the table (and your knowledge of chemical structures) to calculate a value for the amount of energy released if exactly one mole of propane reacts with sufficient oxygen. Clearly show your method of calculation. What is the value of the enthalpy change $(\Delta H)$ for the reaction? (4 marks)

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**Question 9**

For Marker Use Only

*This question assesses Criterion 8.*

If the two gases oxygen and sulfur dioxide are mixed together in a closed container, some sulfur trioxide is formed and an equilibrium is established as described by the equation:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) : \quad \Delta H < 0$$

(a) Write the equilibrium law expression for the reaction. (2 marks)

(b) What would be the effect on the position of equilibrium if some more sulfur dioxide was added to the container and the system allowed to return to the original temperature?

How would this affect the value of the equilibrium constant? Explain both your answers. (4 marks)

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(c) Predict the effect on both the position of equilibrium ***and*** the value of the equilibrium constant if the temperature of the container is lowered without a change in volume. Explain your answers. (3 marks)

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**Question 9 continues opposite.**

**Question 9 (continued)**

**For Marker Use Only**

(d) If the total pressure in the container is increased by adding an inert gas such as helium, Le Chatelier's principle would suggest that the position of equilibrium will move to the product side, thus lowering the total pressure by reducing the total number of particles in the container.

Explain why this does not actually happen. (3 marks)

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**For Marker Use Only**

**Question 10**

*This question assesses Criterion 8.*

When **4.50 mol** of carbonyl chloride ($COCl_2$) is injected into a container of volume **2.00 L** the compound partially decomposes, producing carbon monoxide and chlorine. The equilibrium is described by the equation:

$$\mathbf{COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g) : \Delta H > 0}$$

(a) When equilibrium is established the concentration of the chlorine is found to be **0.15 molL$^{-1}$**. Determine the value of the equilibrium constant. (4 marks)

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(b) Some extra carbonyl chloride **($COCl_2$)** is injected into the container in order to increase the chlorine concentration to **0.200 molL$^{-1}$**, while keeping the volume constant. After the new position of equilibrium is reached, and the temperature has returned to its original value, what is the new concentration of carbonyl chloride? (4 marks)

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**For Marker Use Only**

**Question 11**

*This question assesses Criterion 8.*

The equation for the combustion reaction of ethanol with oxygen gas is:

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$$

The following enthalpy changes (heats of reaction) are available from lists of chemical data:

$$2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l) \qquad \Delta H = -277kJ$$

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -393kJ$$

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g) \qquad \Delta H = -284kJ$$

Use these known enthalpy changes to calculate the amount of energy released by the combustion of one mole of liquid ethanol. (4 marks)

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For Marker Use Only

**Question 12**

*This question assesses Criterion 4.*

The reaction between oxalate ($C_2O_4^{-2}$) ions and acidified permanganate ions ($MnO_4^-/H^+$) is slow at room temperature.

The equation for the reaction is:

$$2MnO_4^- + 5C_2O_4^{-2} + 16H^+ \rightarrow 2Mn^{+2} + 10CO_2 + 8H_2O$$

When 10 drops of the permanganate solution are added to 50mL of the oxalate solution the reaction takes five minutes for the purple permanganate colour to disappear. It is also noticed that the rate of disappearance of the colour speeds up rather than slowing down as might be expected.

When another 10 drops of permanganate are added to the reaction mixture, the purple colour now disappears in a few seconds.

(a) (i) Using your knowledge of the factors which may affect the rates of reactions, develop a hypothesis which would allow you to explain these observations. (2 marks)

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(ii) Explain why your hypothesis fits the observations. (2 marks)

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**Question 12 continues opposite.**

**Question 12 (continued)**

**For Marker Use Only**

(b) How could you test your hypothesis? Any reagents and equipment you require will be made available. (4 marks)

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# Tasmanian Certificate of Education

# CHEMISTRY

## Senior Secondary 5C

*Subject Code: CHM5C*

**External Assessment**

# 2006

## Part 3

**Time: approximately 45 minutes**

On the basis of your performance in this examination, the examiners will provide a result on the following criteria taken from the syllabus statement:

**Criterion 4** Develop and evaluate experiments.

**Criterion 9** Demonstrate knowledge and understanding of the properties and reactions of organic and inorganic matter.

| Criterion | Mark |
|---|---|
| 9 | /32 |
| 4 | /8 |

Pages: 11
Questions: 6

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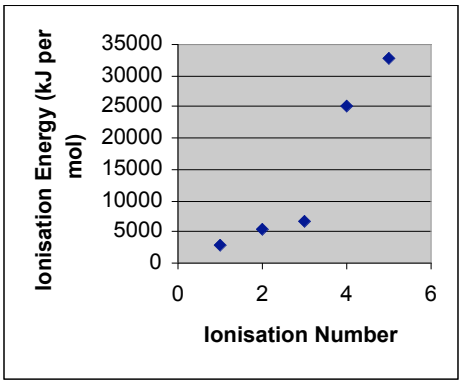
**For Marker Use Only**

**Question 13**

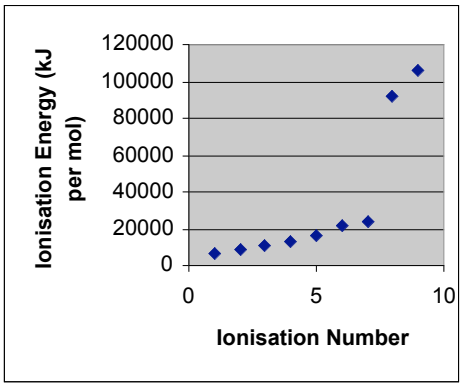
*This question assesses Criterion 9.*

The successive ionisation energies of boron and fluorine are plotted in the following graphs:

Boron




Fluorine




(a) Write down the electron configuration for each element. (1 mark)

Boron: .....

Fluorine: .....

(b) (i) Why is there such a large increase in the ionisation energy required to remove the last two electrons? (2 marks)

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(ii) Using the information on the graphs, explain how the position of the two elements in the Periodic Table can be determined. (3 marks)

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**Question 13 continues opposite.**

**Question 13 (continued)**

**For Marker Use Only**

(c) Write the formula of the compound formed between boron and fluorine and draw its electron dot diagram. (2 marks)

(d) The compound formed between boron and fluorine is a gas at Standard Laboratory Conditions, having a boiling point of **–99.9°C**.

What does this indicate about the type of bonding ***within*** the molecule? Relate this to the size of the boron atom and its position in the Periodic Table. (3 marks)

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**Question 14**

*This question assesses Criterion 9.*

As you go from left to right across a row of the Periodic Table, there is a change from strongly metallic (electropositive) behaviour to strongly electronegative behaviour, which reaches its maximum with the Halogens (Group VII). The next group, the Noble Gases (Group VIII) however exhibit very little chemical reactivity of any kind. Explain this sudden change. (3 marks)

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**For Marker Use Only**

**Question 15**

*This question assesses Criterion 9.*

Write structural formulae for the following organic compounds. (4 marks)

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| 2,2,3-trimethylpentan-3-ol | 2-methylpropanoic acid |
| 1,3,5-trimethylbenzene | 2-iodopentan-3-one |

**For Marker Use Only**

**Question 16**

*This question assesses Criterion 9.*

(a) Write a structural formula equation for the reaction of acetic acid ($CH_3COOH$) and methanol in the presence of concentrated sulfuric acid. (2 marks)

(b) Draw the structural formula of the compound formed when 2-methylpropan-1,2-diol is oxidised with excess acidified permanganate solution. (2 marks)

(c) Glycerol (propan-1,2,3-triol) is a syrupy liquid at room temperature and has a boiling point of $290^{o}C$, which is extremely high for a compound with such a small molar mass. Explain why this is so. (2 marks)

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(d) An addition polymer can be formed using 3-fluoroprop-1-ene as the monomer, using a suitable catalyst. Draw 3 units of the polymer chain. (2 marks)

**For Marker Use Only**

**Question 17**

*This question assesses Criterion 9.*

An organic compound **A** of molecular formula $C_4H_8O$ reacts with acidified permanganate solution. It also reacts with bromine. It does not react with sodium carbonate.

When the product of these reactions, **B**, is purified and dissolved in water it is found to be acidic.

**A** is then reacted with steam using a suitable catalyst producing a compound **C**.

**C** is then completely oxidised with acidified permanganate to produce **D**.

1 mole of **D** reacts to completion with 1 mole of magnesium, producing hydrogen gas.

**D** is also appreciably more acidic than **B**.

Use this information to identify one possible structure for each of the compounds **A**, **B**, **C** and **D**. (6 marks)

| Compound | Possible Structure |
|---|---|
| **A** | |
| **B** | |
| **C** | |
| **D** | |

**For Marker Use Only**

**Question 18**

*This question assesses Criterion 4.*

(a) You have been given three colourless liquids: a ketone, a carboxylic acid, and a secondary alcohol. All three compounds are soluble in water. Describe an experimental procedure, using only two tests, how you could tell which was which. What would you expect to actually observe in each case? (4 marks)

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(b) Suggest some additional tests which would help you to confirm your conclusions in Part (a). (4 marks)

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# Tasmanian Certificate of Education

# CHEMISTRY

## Senior Secondary 5C

*Subject Code: CHM5C*

**External Assessment**

# 2006

## Part 4

**Time: approximately 45 minutes**

On the basis of your performance in this examination, the examiners will provide a result on the following criteria taken from the syllabus statement:

**Criterion 4** Develop and evaluate experiments.

**Criterion 10** Apply logical processes to solve quantitative chemical problems.

| Criterion | Mark |
|---|---|
| 10 | /32 |
| 4 | /8 |

Pages: 11
Questions: 7

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For Marker Use Only

**Question 19**

*This question assesses Criterion 10.*

A polythene weather balloon is released at sea level at an atmospheric pressure of **104 kPa** and a temperature of **25°C**. Under these conditions its volume is **2250 L**. The balloon then ascends to an altitude of 10 000m where the temperature is **–55°C** and the atmospheric pressure has dropped to **24.5 kPa**.

Calculate the volume of the balloon at this altitude if it is able to expand freely. (4 marks)

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**Question 20**

*This question assesses Criterion 10.*

A **3.91 g** sample of a pure gas is found to occupy a volume of **1.75 L** at a temperature of **23°C** and **125 kPa** pressure.

Use this information to determine the relative molar mass of the gas. (4 marks)

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**For Marker Use Only**

**Question 21**

*This question assesses Criterion 10.*

Calculate the mass of the precipitate formed when **125 mL** of **0.250 molL$^{-1}$** aluminium iodide solution is added to **150 mL** of **0.200 molL$^{-1}$** lead(II) nitrate solution. (4 marks)

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**For Marker Use Only**

**Question 22**

*This question assesses Criterion 10.*

A chemist is required to determine the percentage of nickel in an alloy which contains only iron and nickel. A sample of the alloy is finely ground up, and a sample of mass **11.60 g** is added to a dilute sulfuric acid solution until the evolution of hydrogen gas ceases and there is no solid metal remaining. The solution is diluted to a total volume of **100.0 mL** in a volumetric flask.

It can be seen from the table in the Information Sheet that the resulting solution contains $Fe^{+2}$ ions and $Ni^{+2}$ ions. The $Fe^{+2}$ can be further oxidised to $Fe^{+3}$ by titration against a solution of acidified dichromate ions ($Cr_2O_7^{-2}/H^+$). (The nickel is now in its maximum oxidation state and will not be further oxidised by the acidified dichromate).

The equation for the titration reaction is therefore:

$$\mathbf{6Fe^{+2}(aq) + Cr_2O_7^{-2}(aq) + 14H^+ \rightarrow 6Fe^{+3} + 2Cr^{+3} + 7H_2O}$$

(a) To make an approximately $0.2 mol L^{-1}$ dichromate solution. **11.32 g** of potassium dichromate ($\mathbf{K_2Cr_2O_7}$) is dissolved in dilute sulfuric acid and the total volume made up to **200.0 mL** in a volumetric flask.

Calculate the **actual** concentration of the dichromate ions in the resulting solution.

(2 marks)

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**Question 22 continues opposite.**

**Question 22 (continued)**

**For Marker Use Only**

(b) The acidified dichromate ion solution was placed in a burette and titrated against **20.00 mL** samples of the $Fe^{+2}/Ni^{+2}$ solution taken from a pipette. The average volume of the acidified dichromate solution from the burette was **20.80 mL**.

Use this information to determine the concentration of $Fe^{+2}$ in the original solution.
(4 marks)

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(c) What is the percentage by mass of nickel in the alloy? (4 marks)

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**Question 23**

*This question assesses Criterion 10.*

**For Marker Use Only**

A saturated solution of calcium hydroxide ($Ca(OH)_2$) is found to have a pH of 12.4 at standard laboratory temperature.

(a) What is the hydroxide ion concentration in the solution in $molL^{-1}$? (2 marks)

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(b) Calculate the solubility of calcium hydroxide at this temperature in grams per litre if it is present in the solution as calcium ions and hydroxide ions only. (2 marks)

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**For Marker Use Only**

**Question 24**

*This question assesses Criterion 10.*

(a) Determine the number of hours required to electrolytically produce **255 g** of chromium from a solution containing $Cr^{+3}$ ions using a current of **125 amps**. (4 marks)

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(b) What current would be required for the electrolysis to be achieved in 1 hour? (2 marks)

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**For Marker Use Only**

**Question 25**

*This question assesses Criterion 4.*

You are given a **0.500 molL$^{-1}$** solution of an unknown metal M and asked to determine its relative atomic mass.

The following observations were made:

- When **25.0 mL** of the unknown solution was reacted with a **0.25 M** sodium sulfate solution the maximum mass of the resulting precipitate was reached after the addition of **50.0 mL** of the sulfate solution.
- When an electrolytic cell containing the solution of M ions is connected in series with a cell containing a silver nitrate solution and a known current is passed for an hour, the mass of both cathodes increases.

(a) Describe how you would use this information, and any necessary equipment, to determine the relative atomic mass of M. (6 marks)

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**Question 25 continues opposite.**

**Question 25 (continued)**

For Marker Use Only

(b) Do you think it is necessary to know the current applied and duration of the electrolysis in order to achieve the aim of the experiment? Explain your conclusion. (2 marks)

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