

Past-paper walk-through

Electrolysis ■ 24.1

eXercise

Questions in this set

- 9701/42 N25 Q5 ■ 15 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- **//** separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = “or words to that effect” – the wording need not match.

Question 5

9701/42 N25 ■ Q5 ■ 15 marks

- 5** Cobalt is a transition element which forms compounds containing Co^{2+} and Co^{3+} ions. Cobalt(II) sulfate dissolves in water to form a solution containing the $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ complex ion.
- (a) (i)** Complete the electronic configurations of a Co^{2+} ion and a Co^{3+} ion.

Question 5

Question 5

[1]

- (ii) Explain why transition elements can form complex ions.

Question 5

- (iii) An excess of concentrated HCl is added to a solution containing $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$.

Describe the colour change observed and the state of the cobalt-containing product.

Question 5

Question 5

[2]

(iv) Write an equation for the reaction occurring in **(a)(iii)**.

Question 5

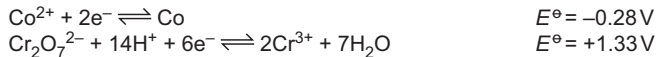
(v) Name the type of reaction occurring in (a)(iii).

Question 5

- (vi) Write an equation for the reaction that occurs when an excess of NaOH(aq) is added to a solution containing $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$.

Question 5

- (b) Cobalt metal can be oxidised by acidified $\text{K}_2\text{Cr}_2\text{O}_7$. The relevant half-equations, and their $E^\ominus$ values, are shown.



- (i) A Co^{2+}/Co electrode is constructed in which $[\text{Co}^{2+}]$ is 0.020 mol dm^{-3} at 298 K .

Use the Nernst equation to show that the E value for this Co^{2+}/Co electrode is -0.33 V .

Question 5

[2]

- (ii) An electrochemical cell is constructed using the Co^{2+}/Co electrode described in **(b)(i)** and a $\text{Cr}_2\text{O}_7^{2-}/\text{Cr}^{3+}$ electrode in which all conditions are standard.

Calculate the value of E_{cell} .

Question 5

- (iii) A current is drawn from the electrochemical cell described in **(b)(ii)**.

Write an equation for the reaction taking place in the cell.

Question 5

- (iv) Complete the sentences to identify the negative electrode and the direction of electron flow when a current is drawn from the cell described in **(b)(ii)**.

Question 5

[1]

(c) A molten Co^{2+} salt is electrolysed using a current of 0.500A.

0.547 g of cobalt metal forms at the cathode. Under the conditions used no other reduction reaction occurs at the cathode.

Calculate the time in minutes for which the current flows to produce this mass of cobalt.

Give your answer to **three** significant figures.

Question 5

[Total: 15] _

Solution 5

(a)(i)

Mark scheme

- $\text{Co}^{2+} = [\text{Ar}] 3d^7$ AND $\text{Co}^{3+} = [\text{Ar}] 3d^6$
- 1

(a)(ii)

Mark scheme

- has vacant d orbitals that are energetically accessible
- 1

Solution 5

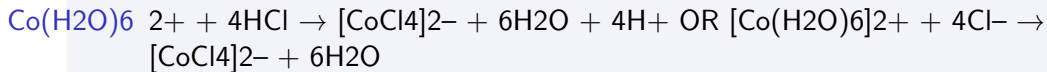
(a)(iii) Mark scheme

- ■
- pink
- ■
- blue
- ■
- aqueous
- Any two [1], all three [2]
- 2

Solution 5

(a)(iv)

Mark scheme



- 1
- 9701/42
- October/November 2025

Solution 5

(a)(v)

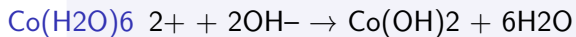
Mark scheme

- ligand exchange
- 1

Solution 5

(a)(vi)

Mark scheme



■ 1

Solution 5

(b)(i)

Mark scheme

- M1: Nernst equation $E = E_o + (0.059 / z) \times \log([\text{oxidised}]$
reduced)
- M2: $E = -0.28 + (0.059 / 2) \times \log(0.02)$
- 2

Solution 5

(b)(ii)

Mark scheme

- 1.66 V
- 1

(b)(iii)

Mark scheme

- $3\text{Co} + \text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ \rightarrow 3\text{Co}^{2+} + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$
- 1

Solution 5

(b)(iv)

Mark scheme

- $\text{Co}^{2+} / \text{Co}$, $\text{Co}^{2+} / \text{Co}$, $\text{Cr}_2\text{O}_7^{2-} / \text{Cr}^{3+}$
- 1

Solution 5

(c)

Mark scheme

- M1: moles of cobalt = $0.547 / 58.9 = 0.00929$
- M2: coulombs required = $0.00929 \times 96500 \times 2 = 1792$
- M3: time required = $1792 / 0.50 = 3584.8 \text{ s} = 59.7 \text{ minutes } 3\text{sf}$
- 3