Chemistry 2019 v1.3

IA1 sample assessment instrument

August 2018

Data test (10%)

This sample has been compiled by the QCAA to assist and support teachers in planning and developing assessment instruments for individual school settings.

Assessment objectives

This assessment instrument is used to determine student achievement in the following objectives:

2. apply understanding of chemical equilibrium systems or oxidation and reduction to given algebraic, visual or graphical representations of scientific relationships and data to determine unknown scientific quantities or features
3. analyse evidence about chemical equilibrium systems or oxidation and reduction to identify trends, patterns, relationships, limitations or uncertainty in datasets
4. interpret evidence about chemical equilibrium systems or oxidation and reduction to draw conclusions based on analysis of datasets.

Note: Objectives 1, 5, 6 and 7 are not assessed in this instrument.

Queensland Government
Queensland Curriculum & Assessment Authority
For all Queensland schools
180960

Subject	Chemistry	**Instrument no.**	IA1
Technique	Data test		
Unit	Unit 3: Equilibrium, acids and redox reactions		
Topic	Topic 1: Chemical equilibrium systems Topic 2: Oxidation and reduction		

Conditions			
Response type	Short response		
Time	60 minutes	**Perusal**	10 minutes
Other	• Length: up to 500 words in total, consisting of – short responses, i.e. single-words, sentences or short paragraphs (fewer than 50 words) – written paragraphs, 50–250 words per item – other types of item responses (e.g. interpreting and calculating) should allow students to complete the response in the set time • QCAA-approved graphics calculator permitted • Chemistry formula and data booklet permitted • Unseen stimulus		
Instructions			
Use the datasets to respond to the associated items in the spaces provided. Each item is associated with the dataset that immediately precedes it.			

Criterion	Marks allocated	Result
Data test Assessment objectives 2, 3, 4	10	
Total	**10**	

Data test summary

Dataset	Item	Objective			
		Apply understanding	Analyse evidence	Interpret evidence	
1	1	1			
	2		3		
	3	1			
	4			2	
	5	3			
2	6		2		
	7	1			
	8		1		
	9			2	
	10			2	
	11			2	
Total		**6**	**6**	**8**	**20**
Percentage		**30%**	**30%**	**40%**	**100%**

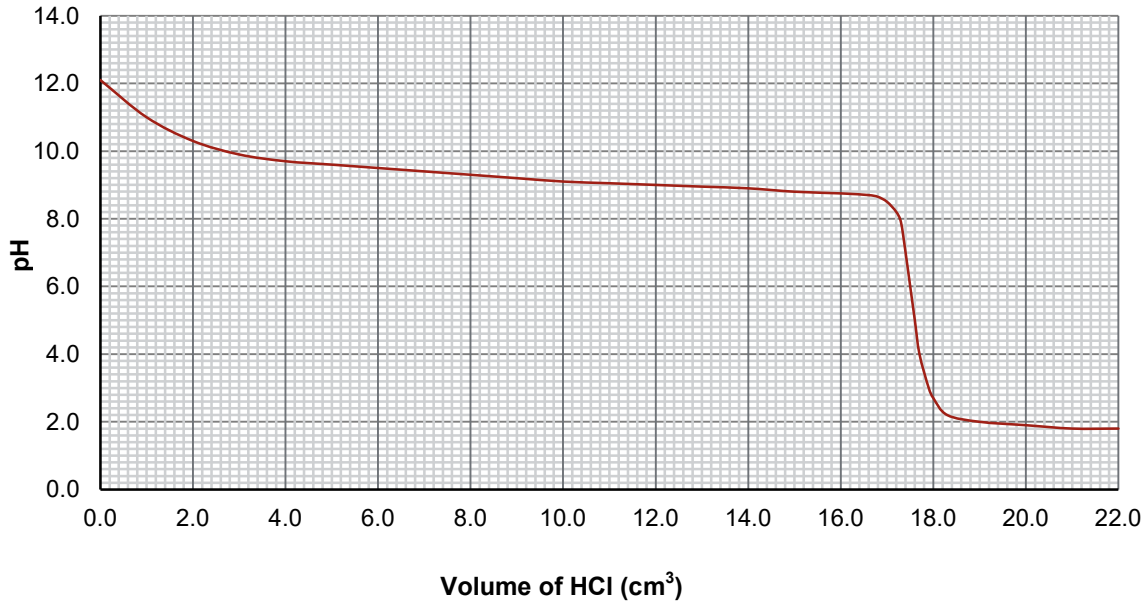
Dataset 1

An experiment was carried out to determine the concentration of ammonia in a cleaning product.
Ammonia dissociates in water to give ammonium and hydroxide according to the following equilibrium:

$$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^{+}{}_{(aq)} + OH^{-}{}_{(aq)}$$

A cleaning product was diluted 1:50. A 25.00 cm^3 sample of the diluted cleaning product was titrated with 0.100 M HCl. The results are shown in Figure 1.

Figure 1: Ammonia solution titrated with HCl



Item 1 (apply understanding) — 1 mark

Determine the pH at the equivalence point. Give your answer correct to one decimal place.

pH = (1 d.p.)

Item 2 (analyse evidence) — 3 marks

Distinguish the half equivalence point from the equivalence point in terms of pH and volume of HCl.

Item 3 (apply understanding) — 1 mark

Determine the pK_a for ammonia. Give your answer correct to one decimal place.

pK_a = (1 d.p.)

Dataset 1

Item 4 (interpret evidence) **2 marks**

Deduce which indicator from Table 13: Acid-base indicators of the *Chemistry formula and data booklet* would be most appropriate for this titration. Give a reason for your conclusion.

Item 5 (apply understanding) **3 marks**

Calculate the concentration of ammonia in the cleaning product. Give your answer correct to three significant figures.

Concentration of ammonia = mol dm^{-3} (3 s.f.)

Dataset 2

An experiment was conducted to address the following research question:

What is the relationship between the reactivity series of metals and the voltage produced by a voltaic cell?

Four unknown metals, labelled A, B, C and D, were each placed into four different 1.0 M metal nitrate solutions. The qualitative results are shown in Table 1.

Samples of metals A, B, C and D were combined with their metal ion solutions to create half-cells. Pairs of half-cells were then combined to construct voltaic cells. The voltages for each voltaic cell are shown in Table 2.

Table 1: Reactions of metals

	Metal ion nitrate solution (1.0 M)			
Metal	**$A(NO_3)_{2(aq)}$**	**$B(NO_3)_{2(aq)}$**	**$C(NO_3)_{(aq)}$**	**$D(NO_3)_{(aq)}$**
$A_{(s)}$	NR	Coating on metal	Coating on metal	Coating on metal
$B_{(s)}$	NR	NR	NR	Coating on metal
$C_{(s)}$	NR	Coating on metal	NR	Coating on metal
$D_{(s)}$	NR	NR	NR	NR

NR = no reaction

Table 2: Potential difference, in volts, for each voltaic cell with anode metal $A_{(s)}$

Voltaic cell	Cathode metal	Potential difference (± 0.05 V)			Mean potential difference (V)	Absolute uncertainty of the mean (± V)
		Trial 1	Trial 2	Trial 3		
1	$B_{(s)}$	2.25	2.40	2.20	2.28	0.10
2	$C_{(s)}$	1.30	1.28	1.37	1.32	0.45
3	$D_{(s)}$	3.11	3.15	3.04	3.10	0.55

Item 6 (analyse evidence) **2 marks**

Sequence the metals from most reactive to least reactive, giving reasons based on the data in Table 1.

Dataset 2

Item 7 (apply understanding) **1 mark**

Identify the voltaic cell that produced the greatest potential difference.

Item 8 (analyse evidence) **1 mark**

Identify the relationship between the difference in reactivity of the metals used to construct a voltaic cell and the potential difference produced by the cell.

Item 9 (interpret evidence) **2 marks**

Deduce whether a voltaic cell constructed using metals B and C as electrodes would produce a greater or smaller potential difference than voltaic cell 1. Give a reason for your answer.

Item 10 (interpret evidence) **2 marks**

Predict which metal would be oxidised in a voltaic cell constructed using metals B and C as electrodes. Give a reason for your answer.

Dataset 2	
Item 11 (interpret evidence)	**2 marks**
Deduce the balanced equation for the voltaic cell constructed using metals B and C as electrodes.	

END OF PAPER

Instrument-specific marking guide (ISMG)

Criterion: Data test

Assessment objectives

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The student work has the following characteristics:	Cut-off	Marks
• consistent demonstration, across a range of scenarios about chemical equilibrium systems or oxidation and reduction, of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual and graphical representations of scientific relationships and data – correct and appropriate use of analytical techniques to correctly identify trends, patterns, relationships, limitations and uncertainty – correct interpretation of evidence to draw valid conclusions.	> 90%	10
	> 80%	9
• consistent demonstration, in scenarios about chemical equilibrium systems or oxidation and reduction, of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual and graphical representations of scientific relationships and data – correct use of analytical techniques to correctly identify trends, patterns, relationships, limitations and uncertainty – correct interpretation of evidence to draw valid conclusions.	> 70%	8
	> 60%	7
• adequate demonstration, in scenarios about chemical equilibrium systems or oxidation and reduction, of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual and graphical representations of scientific relationships and data – correct use of analytical techniques to correctly identify trends, patterns, relationships, limitations and uncertainty – correct interpretation of evidence to draw valid conclusions.	> 50%	6
	> 40%	5
• demonstration, in scenarios about chemical equilibrium systems or oxidation and reduction, of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual or graphical representations of scientific relationships or data – correct use of analytical techniques to correctly identify trends, patterns, relationships, limitations or uncertainty – correct interpretation of evidence to draw valid conclusions.	> 30%	4
	> 20%	3

The student work has the following characteristics:	Cut-off	Marks
• demonstration, in scenarios about chemical equilibrium systems or oxidation and reduction, of elements of – application of scientific concepts, theories, models or systems to predict outcomes, behaviours or implications – calculation of quantities through the use of algebraic or graphical representations of scientific relationships and data – use of analytical techniques to identify trends, patterns, relationships, limitations or uncertainty – interpretation of evidence to draw conclusions.	> 10%	2
	> 1%	1
• does not satisfy any of the descriptors above.	≤ 1%	0