

Chemistry induction tasks 3: Quantitative Chemistry.

Quantitative chemistry is the 'layer' underpinning all experimental chemistry. Without it, other aspects of the subject could never have developed – for instance without quantitative approaches even the simplest formula of a substance would have remained elusive and chemistry would still be the pseudo-science of alchemy!

This induction exercise reviews, reinforces, and introduces new content to your quantitative work.

Hint: If you somehow got through GCSE chemistry hating this type of work, and unable to do it, you need to overcome this problem now. If you cannot, A-level is not an option you should consider as the subject is impenetrable without fluent grasp of these ideas.

Tasks part 1:

Aim to do about 2 hours work and then submit an image (or images) of what you accomplished in the time.

IMPORTANT: All work should be self-assessed according to the following rules:

- **Underline correct parts of work/responses in green; do NOT just tick somewhere on the page;**
- **Add essential words and phrases, also in green, to show development;**
- **Circle / cross out incorrect responses in red. Try to be specific about what was wrong and why.**

Work to complete:

- 1) Chemistry factsheet 02 – required for induction:
 - a. Have a quick scan of the sheet – these approaches are not new. If you need to re-summarise the formulae used in quantitative chemistry then do it!
 - b. If you are a more visual learner, these links could help:
 - i. <https://www.youtube.com/watch?v=jCynTWTwjpw>
 - ii. <https://www.youtube.com/watch?v=yjoaLNx00Ps>
 - c. Next, try the relevant factsheet questions and self-assess them (using the guidance given above) as evidence of improvement.
 - d. Now, lets try some 'real' exam questions – on the following page.
 - e. Submit your IMPROVED, assessed answers to these questions (one page) as part of your evidence bundle.

Questions

Q1. Nickel is an element in the d-block of the Periodic Table.

(a) Complete the electronic configuration of a nickel atom using the s, p, d notation.

(1)

1s²

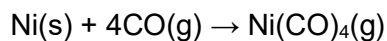
(b) A sample of nickel is made up of three isotopes. The percentage abundances are shown in the table below.

Isotope	Percentage abundance
⁵⁸ Ni	69.02
⁶⁰ Ni	27.32
⁶² Ni	3.66

Calculate the relative atomic mass of nickel. Give your answer to **two** decimal places.

(2)

(c) Nickel reacts with carbon monoxide, CO, to give the compound nickel carbonyl, Ni(CO)₄.



(i) Calculate the volume of carbon monoxide, in dm³, measured at room temperature and pressure, that is required to react completely with 5.87 g of nickel.

[Relative atomic mass: Ni = 58.7

Molar volume of a gas = 24 dm³ mol⁻¹ at room temperature and pressure.]

(3)

(ii) Calculate the **number** of carbon monoxide molecules present in the volume of gas you have calculated in (c)(i).

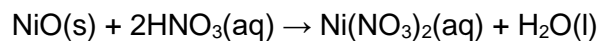
[The Avogadro constant, $L = 6.02 \times 10^{23} \text{ mol}^{-1}$]

(1)

(d) Nickel(II) nitrate, $\text{Ni}(\text{NO}_3)_2$, can be made by several different methods.

Method 1

Nickel(II) oxide, NiO , was reacted with dilute nitric acid according to the equation



(i) Calculate the volume of 2.00 mol dm^{-3} dilute nitric acid, in cm^3 , that was required to exactly neutralize 1.494 g of nickel(II) oxide.

Use the relative atomic masses: $\text{Ni} = 58.7$, $\text{O} = 16.0$

(3)

Method 2

A volume of 25.0 cm³ of 2.00 mol dm⁻³ nitric acid, HNO₃, was transferred to a beaker. Solid nickel(II) carbonate, NiCO₃, was added until it was in excess.

(ii) Why was **excess** nickel(II) carbonate used?

(1)

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(iii) Why must the beaker be **much** larger than the volume of acid used?

(1)

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.....

(iv) Write a balanced equation for the reaction between nickel(II) carbonate and dilute nitric acid, including state symbols.

(2)

*(v) For **Method 2**, describe the practical steps that you would take to obtain pure dry crystals of hydrated nickel(II) nitrate, Ni(NO₃)₂.6H₂O, from a mixture of nickel(II) nitrate solution and unreacted solid nickel(II) carbonate.

(4)

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(Total for question = 18 marks)

Mark Scheme

Q1.

Question Number	Acceptable Answers	Reject	Mark
(a)	$(1s^2) 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$ OR $(1s^2) 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$ ALLOW capital S P D Allow subscripts (e.g. $(1s^2) 2s_2 2p_6 3s_2 3p_6 4s_2 3d_8$)		1

Question Number	Acceptable Answers	Reject	Mark
(b)	$(A_r \text{ for Ni}) = (58 \times 0.6902) + (60 \times 0.2732) + (62 \times 0.0366)$ or a correct fraction using percentages (1) $(= 58.6928)$ [calculator value] $= 58.69$ (must be to 2 dp) (1) 2 nd mark CQ on numbers transcribed Correct answer with no working (2) IGNORE Units of any kind (e.g. 'g', 'g mol ⁻¹ ', 'amu', etc.)	58.68 (as rounding error)	2

Question Number	Acceptable Answers	Reject	Mark
(c)(i)	Moles of nickel = $\frac{5.87}{58.7}$ $= 0.1(00)$ (mol) (1) Moles CO = $0.1(00) \times 4 = 0.4(00)$ (mol) Answer CQ on 4 x mol Ni (1) Volume of CO = $0.4(00) \times 24$ (dm ³) $= 9.6$ (dm ³) ALLOW 9600 cm ³ Answer CQ on 24 x mol CO (1) Correct answer with no working scores (3)	9.6 dm ³ mol ⁻¹ (no 3 rd mark) 9.6 dm ⁻³ (no 3 rd mark) OR Any other incorrect units (no 3 rd mark)	3

Question Number	Acceptable Answers	Reject	Mark
(c)(ii)	(Number of CO molecules $= 0.400 \times 6.02 \times 10^{23}$) $= 2.408 \times 10^{23}$ Answer CQ on moles / volume of CO in (c)(i) IGNORE sf except 1 sf IGNORE Any units, even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
(d)(i)	<p>Moles of NiO = $\frac{1.494}{74.7}$ = 0.02(00) (mol) (1)</p> <p>Moles HNO₃ = 0.02(00) x 2 = 0.04(00) (mol)</p> <p>Answer CQ on 2 x mol NiO (1)</p> <p>Volume of HNO₃ = $\frac{0.04(00) \times 1000}{2.00}$ = 20(.0) (cm³)</p> <p>ALLOW 0.02(00) dm³</p> <p>Answer CQ on mol HNO₃ (1)</p> <p>Correct answer with no working scores (3)</p> <p>Penalise wrong units ONCE only</p>		3

Question Number	Acceptable Answers	Reject	Mark
(d)(ii)	<p>To ensure all the acid reacts / all the acid is used up / all the acid is neutralized</p> <p>IGNORE References to 'yield' / reaction going to completion / just 'acid is the limiting reagent'</p>	To ensure all the reactants are used up	1

Question Number	Acceptable Answers	Reject	Mark
(d)(iii)	<p>Fizzing / effervescence / frothing / bubbles / gas released</p> <p>IGNORE spilling (over) / spillage References to 'vigorous', 'exothermic', 'violent' / just 'safety'</p>	<p>(Mixture) boils</p> <p>Quantity of reagents / 'displacement' of solution on adding solid</p>	1

Question Number	Acceptable Answers	Reject	Mark
(d)(iv)	<p>NiCO₃(s) + 2HNO₃(aq) → Ni(NO₃)₂(aq) + H₂O(l) + CO₂(g)</p> <p>ALLOW correct ionic equation</p> <p>NiCO₃(s) + 2H⁺(aq) → Ni²⁺(aq) + H₂O(l) + CO₂(g)</p> <p>All species correct (1)</p> <p>Balancing and all state symbols correct (1)</p> <p>2nd mark is dependent on 1st mark (ie all species correct)</p>	H ₂ CO ₃ (aq) scores (0) overall	2

Question Number	Acceptable Answers	Reject	Mark
* (d)(v)	<p>First mark: Filter (off the excess nickel(II) carbonate / solid) (1)</p> <p>Second mark: Boil / heat (to drive off some of the water) (1)</p> <p>IGNORE just 'evaporation' (as the technique of boiling / heating is required here)</p> <p>Third mark: Leave to cool / leave to crystallize / evaporate (water) slowly / leave (for water) to evaporate (1)</p> <p>Fourth mark: Dry (the crystals) (1)</p> <p>IGNORE Any washing of the crystals immediately prior to drying them</p> <p>NOTE If heat to dryness in the second stage, award (1) mark if filtration is first stage</p> <p>If filtration is not the first stage, award (1) mark for steps 2, 3 and 4 all correct</p>	<p>Just "warm" the filtrate / solution OR 'heat the filtrate to dryness'</p> <p>(Adding to a) drying agent</p> <p>Use of Bunsen burner or direct heating to dry crystals</p>	4

Further work (not required for induction but a very good idea to smooth your transition over the summer)

Tasks:

- Use a similar structure to the task I set out earlier in the document.
- There is no need to submit any of this to me.
- Base your further 'quantitative chemistry' work on the factsheets 3,7,107 (in that order)

Important:

- This work really shouldn't be a shock to you – calculations are here to stay!
- Although you can study calculation types in isolation, only exposure to real exam questions will train you to become an effective user of the techniques – you may be surprised by how hard you found the questions. This is because you did not practice in contextual situations – only abstract ones.
- However, to be clear, this IS the level you have to work at from September (though with a LOT more teacher guidance, of course!)
- In summary, the induction again shows the initial level of challenge, but without the support. This means if you can do it without guidance (or even just a proportion of it) then you have the 'right stuff'!