# DM.a-n - Developing Metals | DM1-6 |

## DM.Q Exam questions from past papers

| Complete the diagram below that shows the Ecell value (5)?  Calculate the Ecell value (1) ? | * Pt electrode for Fe3+ / Fe2+ half cell (1) * In Fe3+ / Fe2+ (1) * Cu electrode in Cu2+ (1) * Salt bridge labelled and in solutions (1) * Conditions: 1moldm-3 and 298K / 25C (1) * 0.43V (1)   *If a half cell was VO2+ + 2H+ + e- -> VO2+ + H2O then a label for* ***H+ would also be required*** |
| --- | --- |
| Suggest why rusting takes place faster in seawater than in rainwater? | * Faster in sea water as more dissolved ions makes it a better conductor |
| The students wants to use this electrode to measure the standard electrode potential of a Fe/Fe2+ half cell  Give instructions on how to do this justifying the uses of the pieces of apparatus you name.  [You may add to the diagram to illustrate ur answer] | Set up:   * Make sure reading on voltmeter is positive * Electrode/half cell connected to positive terminal of voltmeter is the positive electrode * From knowing   Description of the apparatus used and why:   * High resistance voltmeter so negligible current is taken (so conc’s of ions stay the same) * Salt bridge to keep the charge in each half cell constant * Draw complete electrochemical cell ;) * Fe(s) electrode   Conditions/Conc   * 298K/25C * 1moldm-3 in Fe/Fe2+ |

## DM.a - Formulae, equations & amount of substance | DM1 |

| What acid should be used for manganate redox titrations? Why? | Excess dilute sulfuric acid as other acids can set up alternative redox reactions (leading to inaccurate titres) as seen below |
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| Why is an indicator not required for a manganate sulfuric acid redox titration and its colour change? | As manganate (MnO4-) is pink (the only coloured reagent) and so when it's reduced it produces Mn2+ which is colourless and the endpoint is when the pink reappears  *MnO4- (aq) + 8H+ (aq) + 5Fe2+ -> Mn2+ (aq) + 4H2O (l) + 5Fe3+ (aq)* |
| Why must EXCESS sulfuric acid be used in a manganate sulfuric acid redox titration | Otherwise, the solution won’t be acidic enough and MnO2 will be produced instead of Mn2+  *Remember MnO4- (aq) + 8H+ (aq) + 5Fe2+ (aq) -> Mn2+ (aq) + 4H2O (l) + 5Fe3+ (aq)* |
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## DM.b - Bonding & Structure | DM6 |

| Define coordination number? | The number of coordinate bonds formed to a central metal ions.  ***This won’t always equal the number of ligands******like here:***      *Coordinate bonds are the same thing as a dative covalent bond* |
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| What are the shape and bond angles of the complexes with the different coordinate numbers? | * Coordinate number 2 - Linear structure - 120 degrees * Coordinate number 4 - Tetrahedral structure - 109.5 degrees      * Coordinate number 4 - Square planar structure - 90 degrees      * Coordinate number 6 - Octahedral structure - 90 degrees     *A question would state or imply that a structure with coordinate number 4 is either tetrahedral or square planar or both would be an acceptable answer*  *Complexes with other coordinate numbers not stated above are not required for this spec this includes 8* |
| Draw the shape of the complex of Cisplatin [Pt(NH3)2(Cl)2] as a square planar structure? |  |
| Draw the shape of the complex of [CuCl4]2- as a tetrahedral structure? |  |
| Draw the shape of the complex of [Cu(H2O)6]2+ as an octahedral structure? (3) |  |

## DM.c-f - Redox | DM4 | DM5 | FOCUS ON THIS ONE ITS ON THE PRELEASE 2025 GUARANTEED TO COME UP ON Scientific Notice Paper 2

| How can half-equations containing 12O be balanced? | 1. Check that the element that is changing oxidation state is initially balanced i.e MnO42-> Mn2+ checking Mn atoms are balanced 2. Hydrogen ions and waters - balance atoms using H+ and H2O 3. Oxidation - balance charges using electrons 4. Check - check that atoms and charges balance.   *This can be remembered as dodgy CHOC*  *You could also do the longer way by balancing the equation using oxidation states* |
| --- | --- |
| **What is the method for setting up electrochemical cells from textbook?** | 1. Construct the half-cell whose electrode potential is to be measured. For a metalion/metal half-cell (e.g., the Cu2+/Cu half-cell), the electrode will be made from the metal which its ionic form in the solution. If the reaction involves two ions the same element in different oxidation states (e.g., Fe3+/Fe2+) the electrode should be either platinum or carbon (graphite) the solution will contain a mixture of the two ions. Ensure cases all the solutions have a conc of 1M are at 298K 2. Connect the half-cell to a standard hydrogen half-cell or other reference cell using a high-resistance voltmeter and salt bridge 3. Connect the two electrodes to a high resistance voltmeter and salt bridge [Figure 21] 4. Record the voltmeter reading - in the case of a measurement taken using a hydrogen half-cell this value is the required EMF EOcell |
| What do simple half-cells usually consist of? | A metal (acting as an electrode) and a solution of compound containing said metal. Eg, Cu and CuSO4    Usually as if there was a CrO72- to Cr3+ half reaction then a platinum/graphite electrode has to be used  *The electrode in this case is not an anode/cathode as this is not electrolysis its electrochemistry ‘they are built differently’ think of the meme :)* |
| When is a inert platinum electrode used in electrode potentials and why? (with example) | * When the half equation doesn’t contain a solid * E.g. Fe3+ (aq) + e- ⇌ Fe2+ (aq) |
| What causes the transfer of charge through the solutions and the wire of an electrochemical cell (2) | * The transfer of charge through the solution is caused by the ions (1) * The transfer of charge through the wire is caused by electrons (1)   *This is measured using a high-resistance voltmeter to stop current from flowing whilst preventing p.d. Preventing reaction. If this was replaced with a bulb, current will flow. Reactions will then occur at each electrode yet the voltage would fall to zero as the reactants are used up.* |
| What is the salt bridge made up of in electrochemical cells and its purpose (structure and reason) (3) | * Usually filter paper with KNO3 solution (1) * Allows ions to flow between half cells (1) which completes the circuit (1)   *Allows ions to form preventing imbalance (which would otherwise repel incoming metals).*  *The salt should be unreactive. Eg, KCl will form complexes instead* |
| **Why isn’t a wire used as the ‘salt bridge’?** | It would set up its own electrode system with solutions |
| Which direction do electrons flow in electrochemical cells? | * From Cu to Ag as Cu electrode potential is more negative (1) * Or Ag electrode potential is more positive   *From whichever electrode does oxidation to the reduction electrode* |
| Define standard electrode potential of a half-cell (E𝝝)? | The voltage measured under standard conditions when the half-cell is connected to a standard hydrogen electrode  *This is by convention, we cannot measure an absolute potential for obvious reasons* |
| What do standard electrode potentials tell us? | * The measure of the ability of a species to gain electrons. The more positive E**𝝝** is, the stronger the ability. * When connected in a hydrogen electrode system. |
| What is the standard hydrogen electrode (SHE), its equation with standard conditions (1moldm-3, 298K and 1atm/100kPa)? | * A half cell using hydrogen * Has the following equilibrium: H2 (g) ⇌ 2H+ (aq) + 2e-     ***Details of the set-up of the hydrogen electrode are not required for this specification***  Indirectly used by using a different standard electrode (which is calibrated against the SHE) since it’s easier to use. |
| How do you work out the electrode potential of a cell? | * E𝝝cell = E𝝝more positive - E𝝝more negative * The more positive E𝝝 at a half cell would always reduce     *Could also think about it as Ecell = Ereduction - Eoxidation* |
| How can electrode potentials be used to predict the feasibility of reactions and why might a reaction not occur  For instance if we had a mixture only of MnO4- and Zn or Mg2+(aq) and Zn(s)? | * Zn(s) and MnO4- would react as MnO4- can be reduced by Zn * Zinc will lose electrons (oxidised) that will be **transferred** to the MnO4- * Zn2+/Zn has a more negative E𝝝 than MnO4-/Mn2+   Whilst   * Mg2+ and Zn would not react as Mg2+/Mg has a more negative E𝝝 than Zn2+/Zn so Zn(s) would not be oxidised by Mg2+ |
| What’s wrong with using electrode potentials to determine the feasibility of whether a reaction occurs? 2 reasons | * The reaction may have a high activation enthalpy * Conditions may not be standard   *The rate of reaction may be slow that it appears not to be happening may be another reason* |
| How does increasing the concentration of Zn2+ affect cell potential Ecell? (2) | * The POE shifts to the left which reduces the loss of electrons * Therefore the E𝝝 becomes less negative (1) and so the cell potential decreases (1)   *By Le Chatlier’s, increasing [reactants] increases* E𝝝 |
| How does increasing the concentration of Cu2+ affect cell potential Ecell ? (2) | * The POE shifts to the right which increases the gain of electrons * Therefore the E𝝝 becomes more positive (1) and so the Ecell increases (1)   *By Le Chatlier’s, increasing [reactants] increases* E𝝝 |
| How does temperature affect cell potential Ecell? | Most cells are exothermic in the forward direction. Using Le Chatelier’s increasing temperature decreases Ecell |
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| What are the 3 stages of rusting [equations]? With colours of ppt and state symbols | 1. (green rust) 2. Fe2+ -> Fe3+ + e- (think about electron config) then Fe3+ (aq) + 3OH- (aq) -> Fe(OH)3 (s) or Fe2O3.xH2O (s) would also occur to produce orange rust   *Stage 3 occurs due to Fe3+ being more stable than Fe2+ as Fe3+ has a partially filled d subshell which is more stable than a full or empty d subshell*  *Rusting is a type of corrosion* |
| How does having alkaline conditions affect the process of rusting? | * Increase in [OH-] makes the POE for 0.5O2 + H2O + 2e- ⇌ 2OH- shifts to the left to reduce [OH-] which produces electrons * Then the POE for Fe2+ + 2e- ⇌ Fe shifts to the right due to the extra electrons produced * Therefore the [Fe2+] decreases which produces less rust |
| What are the preventive methods against rusting? | Barrier methods:   * Lubricating * Painting * Coating with a polymer * Oiling/greasing   Sacrificial method:   * Using a sacrificial metal, e.g zinc, and so Zn would be oxidised instead of Fe * Galvanising by spraying zinc onto an object or using blocks of zinc like on a ship     **^**Zn is acting as a sacrificial metal as it has more negative electrode potential |

## DM.g-m - Inorganic chemistry & the periodic table | DM1 | DM2 | DM3 | DM6 |

| Define a transition metal? | A d block element with at least one ion with a partially filled d subshell  E.g, Cu has [Ar] 3d104s1 where Cu2+ has [Ar] 3d94s0  *For this spec when referring to the d block elements its only from scandium (3d1) to zinc (3d10) unless a question states otherwise* |
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| Why aren’t zinc and scandium transition elements? | * Zinc can only form 2+ ion which has a complete d-subshell   + Zn has [Ar] 3d10 4s2 whereas Zn2+ has [Ar] 3d10 4s0 * Scandium can only form 3+ ions which has an empty d-subshell   + Sc has [Ar] 3d14s2 whereas Sc3+ has [Ar] 3d04s0 |
| What are the characteristics of all transition elements? | * Form coloured compounds (coloured ions) * Variable oxidation states (Eg, Fe (II) and Fe (III) * Catalysts * Form complex ions (in solution)   *They form coloured ions due to their electronic configuration* |
| What is always true for when a d block element becomes an ion? | Whenever d block elements form ions the 4s electrons are lost FIRST |
| Which transition metals have anomalous electron structures and why? | * Copper - [Ar] 3d10 4s1 and chromium [Ar] 3d5 4s1 * They have a half built/full built 3d subshells is lower in energy than a full built 4s subshell |
| Define ligand? | An atom, ion, or molecule that uses its lone pair of electrons to form a coordinate bond to a central metal ion  *This bonds occurs through the ligand lone pairs of electrons* |
| Define complex/complex ion? | A central metal ion surrounded by ligands |
| How are (aq) complex ions written? | * When they contain ligands that aren’t water or hydroxide ions, you need to include all water ligands. * Eg, [Cu(NH3)4(H2O)2]2+ cannot be rewritten whereas [Cu(OH)2(H2O)4]2+ can be written as Cu(OH)2 |
| Define monodentate ligand? (with examples of both ligands and complex ions) | * Ligand that forms 1 coordinate bond to a central metal ion * Examples include: H2O, NH3 and Cl-, CN- * One is used as shown below:     [Cu(H2O)6]2+ in this case could also be written as Cu(aq)  *In this case, the water ligands have no charge so the charge stays as 2+ from Cu2+* |
| Define bidentate ligand? (with examples of both ligands and complex ions) | * Ligands that forms 2 coordinate bonds to a central metal ion * Examples include: C2O42- (ethanedioate), C2H4(NH3)2 (ethene-1,2-diamine) * This is used as shown below with Fe (III)     [Fe(C2O4)3]3-  *Each ligand reduces the charge by 2. You have 3 hence 3- Charge* |
| Define polydentate ligand (with an example) | * Ligands that can form **more than one coordinate bond** to a central metal ion * Examples include: EDTA4- (forming 6 coordinate bonds)     *In this case, it would be a hexadentate but don’t worry about it*  *Don’t say it is a ligand that can form more than 2 coordinate bonds or any specific number of coordinate bonds as its* ***wrong from Mark Scheme see below*** |
| **Define Ligand substitution (Ligand exchange reaction)?** | When one ligand is swapped for another ligand  *Also known as ligand displacement* |
| Describe how iron(II) reacts with hydroxide ions and ammonia (with colours and equations)? | * Fe2+ (aq) + 2OH- (aq) -> Fe(OH)2 (s) * Fe2+(aq) + 2NH3 (aq) -> Fe(OH)2 (s) + 2NH4+ (aq)   + Via NH3(aq) + H2O ⇌ OH- (aq) + NH4+ (aq) * From pale green solution to green ppt   *Depending on the conditions Fe2+ can be oxidised to Fe3+ so it would make an orange ppt instead so look out for that like down here*    Answer is A btw  *Fe(II) DOES NOT FORM COMPLEXES WITH AMMONIA* |
| Describe how iron(III) reacts with hydroxide ions and ammonia (with colours and equations) | * Fe3+ (aq) + 3OH- (aq) -> Fe(OH)3 (s) * Fe3+ (aq) + 3NH3 (aq) -> Fe(OH)3 (s) + 3NH4+   + Via NH3(aq) + H2O ⇌ OH- (aq) + NH4+ (aq) * Goes from a yellow solution to an orange ppt   *Fe(III) DOES NOT FORM COMPLEXES WITH AMMONIA* |
| Describe the reaction of copper (II) with hydroxide ions (with colours and equations) | * Cu2+ (aq) + 2OH- (aq) -> Cu(OH)2 (s) * Goes from pale blue solution to a blue ppt (since no charge)   *[Cu(H2O)6]2+ (aq) + 2OH- (aq) -> [Cu(H2O)4(OH)2] (s) + 2H2O (l)* |
| Describe the reaction of copper (II) with ammonia and excess ammonia (with colours and equations and the properties of ammonia for each reaction)? | * [Cu(H2O)6]2+ (aq) + 2NH3 (aq) -> Cu(OH)2 (s) + 2NH4+ (aq) Occurs from:   + NH3(aq) + H2O ⇌ OH- (aq) + NH4+ (aq)   + Cu2+ (aq) + 2OH- (aq) -> Cu(OH)2 (s) * Goes from pale blue solution to a blue ppt * During this process, Ammonia acts as a base * In excess NH3, Cu(OH)2 (s) reacts further to form [Cu(NH3)4(H2O)2]2+ (aq) * Which is from the blue ppt to a dark blue solution as ppt dissolves * During this process, Ammonia acts as a ligand   *This occurs via ligand substitution (ligand exchange reaction)* |
| How does Homogeneous and Heterogeneous catalytic activity of a transition metal differ from the standard? | * Homogeneous - They use their variable oxidation states * Heterogeneous - During adsorption they use their (3)d and (4)s electrons of the atoms on the catalyst surface to form weak bonds to reactants   *The majority of the time it would be the 3d or 4s electrons but it would differ if they don’t use 4th-period transition metals* |
| Why are complex ions coloured? (3) | * The d orbital (or d subshell) are split by ligands (1) * Electrons get excited and move to a higher energy level when they absorb visible light via ΔE=hv (1) * Colour transmitted is complementary to the frequency absorbed (1)     *Don’t accept E=hv need the delta says on MS*  Therefore different complex ions/different ligands would have a different sized gap and different colours as they would absorb a different frequency of colour and transmit a different complementary colour  *I’ve only really seen them mention d orbital splitting in past papers not d subshell* |
| What are 3 factors that would affect the gap size when ligands split d subshells/orbitals in complex ions? | * Different ligands * Different central metal ion * Different oxidation state (of central metal ion) * Different coordinate number (from CGP guide) |
| What are the 3 pairs of complementary colours? | * Red and green * Blue and orange * Violet and yellow     *So when a compound absorbs red wavelengths, it transmits (or reflects) the complementary colour green and so green is what seen*  *Do not allow ‘emit’ light* |

## DM.n - Energy & Matter | DM3 |

| What is the method for finding the concentration of an unknown solution using colorimetry/visible spectrophotometer? [Including fine detail] and Mnemonic  [Mrs Marsden Script] | Setting up colorimeter:   * **Choose** a suitable filter / wavelength of colorimeter, showing greatest absorbance/complementary colour \* * **Zero** colorimeter using a cuvette of water \*   Calibration:   * **Make** up 5 or more **standard solutions** of coloured compound/transition metal for which the concentration is known [Minimum of 5 different concentrations, use a burette to take accurate volume readings, use concentrations more and less than the unknown] * **Measure** the absorbance for each **known** concentration of diluted standard solutions [ensure each sample is in a clean cuvette] * **Plot** a calibration curve of absorbance against concentration and draw a line of best fit   Measuring unknown:   * **Measure** the absorbance of **unknown** sample and use calibration curve to determine the concentration of unknown solution \*   \* May be achieved by drawing a diagram  Remember this as CZMMPM  Choosing Zero Measurements Mass Produces Moles    *Remember control variables which could be keeping temperature constant or use the same total volume of solution in each cuvette bestie🙂* |
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