1.What is the atom economy for making ammonia via 2NH4Cl(s) + Ca(OH)2(s) → CaCl2(s) + 2NH3(g) + 2H2O(g)?

**[1 mark]**

**1)** 0%

**2)** 0–50%

**3)** 50–99%

**4)** ≥ 100%

2. 4 g of calcium reacts with excess hydrochloric acid. How many moles of calcium react?

**[1 mark]**

Ca + 2HCl → MgCl2 + H2

*A*r(Ca) = 40

**1)** 4

**2)** 1

**3)** 0.1

**4)** 40

3. Iron reacts with excess fluorine gas. The mass of products is measured. Use these numbers to find **X** and balance the equation.

**[1 mark]**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Fe | + | **x**/2F2 | → | FeF**x** |
| 5.6 g |  | excess |  | 11.3 g |

*A*r(Fe) = 56; *A*r(F) = 19

**1)** 2

**2)** 3

**3)** 4

**4)** 1/3

**4a.** Explain the purpose and principle of titration.

**[2 marks]**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**b.** A titration was carried out to calculate the concentration of 30.00 cm3 of hydrochloric acid with 0.150 molar sodium hydroxide. The titration was repeated another five times. These are the results, excluding the trial:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 18.25 cm3 | 21.75 cm3 | 22.00 cm3 | 17.75 cm3 | 20.25 cm3 |

What is the concentration of the hydrochloric acid?

**[4 marks]**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. Match the percentage yield to the actual and theoretical yields.

**[2 marks]**

|  |  |  |
| --- | --- | --- |
| 9 g of potassium hydroxide, out of a maximum 11 g |  | 82% |
| 4 g of ammonia, out of a maximum 17 g |  | 24% |
| 7 g of calcium nitrate, out of a maximum 9 g |  | 78% |
| 2 g of potassium hydroxide, out of a maximum 8 g |  | 25% |

6. Which one of these equations correctly shows the formation of a **metal** **ion**?

**a)** Mg → Mg2+ + e−

**b)** Li → Li+ + 2e−

**c)** Na → Na+ + e−

**d)** O2 + 2e− → 2O2−

7. Look at this diagram showing what happens to atoms of sodium and chlorine when they combine:

What type of reaction does this show?

**a)** Redox

**b)** Oxidation

**c)** Reduction

**d)** No reaction

Answer [1 mark]

8. Calculate the energy change of the reaction: CH4 + 2O2 🡪 CO2 + 2H2O

|  |  |
| --- | --- |
| C–H | 412 kJ mol−1 |
| O=O | 498 kJ mol−1 |
| C=O | 532 kJ mol−1 |
| H–O | 465 kJ mol−1 |

 **[1 mark]**

**a)** +280 kJ mol−1

**b)** +716 kJ mol−1

**c)** –280 kJ mol−1

**d)** –716 kJ mol−1

**9.** Which one of the following statements is true regarding bond energies?

**[1 mark]**

**a)** Breaking bonds is an exothermic process

**b)** If less energy is needed to break bonds than is released in making new bonds, then a reaction is endothermic overall

**c)** Activation energy is the energy needed to join two atoms together

**d)** If less energy is needed to break bonds than is released in making new bonds, then a reaction is exothermic overall

10. Aluminium metal is put into a solution of silver sulphate. Which of the following equations correctly shows what will occur?

**[1 mark]**

**a)** Al3+ + 3Ag 🡪 Al + 3Ag+

**b)** Al + 3Ag+ → Al3+ + 3Ag

**c)** Al3+ + 3e− 🡪 Al

**d)** Ag + e− 🡪 Ag−

11. A redox reaction occurs in a hydrogen fuel cell. Match the following phrases to make logical pairs

**[2 marks]**

|  |  |  |
| --- | --- | --- |
| Reduction \_\_ |  | loss of electrons |
| 4H+ + O2 + 4e− → 2H2O is \_\_ |  | occurs at the positive electrode |
| Oxidation is the \_\_ |  | at the negative electrode |
| Hydrogen atoms form hydrogen ions \_\_ |  | an example of a reduction reaction |

**12.** Match these equations to the type of reaction they represent.

**[2 marks]**

|  |  |  |
| --- | --- | --- |
| Mg 🡪 Mg2+ + 2e− |  | Reduction |
| Ca2+ + 2e− 🡪 Ca |  | Oxidation |
| HCl + NaOH🡪NaCl + H2O |  | Displacement |
| Mg + Zn2**+ →** Mg2+ + Zn |  | Neutralisation |

**13.** Describe the difference between reduction and oxidation in terms of electron transfer. State which process is occurring in this reaction:

 Mg 🡪 Mg2+ + 2e−

**[3 marks]**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

14. Calculate the energy change for the reaction:

 2C2H6 + 7O2 🡪 4CO2 + 6H2O

**[3 marks]**

|  |  |
| --- | --- |
| C–H | 412 kJ mol−1 |
| O=O | 498 kJ mol−1 |
| C=O | 532 kJ mol−1 |
| H–O | 465 kJ mol−1 |
| C–C | 368 kJ mol−1 |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

15. Look at this diagram of a chromatogram. What is A?



**a)** Pink litmus paper

**b)** Blue litmus paper

**c)** pH paper

**d)** Chromatography paper

16. A student carried out chromatography to separate a mixture of inks. The student observed that a red spot had moved 10.2 cm from the base line. The solvent front had moved 14.5 cm. What is the correct *R*f value of this spot?

**a)** 1.42

**b)** 4.30

**c)** 0.913

**d)** 0.703

17. The results of a chromatography run are shown here:



Calculate the *R*f values of A−D and explain which substances are found in the sample.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Marking Scheme

Question Answer

|  |  |
| --- | --- |
| 1 | 0–50% |

|  |  |
| --- | --- |
| 2 | 0.1 |
| 3 | 3 |

|  |  |
| --- | --- |
| 4ab | Purpose: To determine concentration of unknown solution: Principle: Slow addition of a solution of known concentration (titrant) to solution of unknown concentration, but known volume, until reaction neutralises, often indicated by a (rapid) colour change; number of moles of titrant (known) = number of moles of unknown concentration solution (calculated): Find the mean of the titration results, total and divide by five = 20 cm3 = 0.02 dm3 : 1:1 molar ratio NaOH + HCl → NaCl + H2O: Substitute figures into equationCorrect conversion of units and use of correct units throughout workings.  |

|  |  |
| --- | --- |
| 5 | 9 g of potassium hydroxide, out of a maximum 11 g – 82%4 g of ammonia, out of a maximum 17 g – 24%7 g of calcium nitrate, out of a maximum 9 g – 78%2 g of potassium hydroxide, out of a maximum 8 g – 25% |

|  |  |
| --- | --- |
| 15 | D |

|  |  |
| --- | --- |
| 16 | D |

|  |  |
| --- | --- |
| 13 | *R*f values: A = 0.89; B = 0.51; C = 0.80; D = 0.23 (sample green spot = 0.63); Sample contains substances C and D (similar *R*f values), and another unknown substance, no reference *R*f value (green spot); Does not contain substances A and B, no dye appeared from the sample at the *R*f values of A and B |

|  |  |
| --- | --- |
| 6 | C |

|  |  |
| --- | --- |
| 7 | A |

|  |  |
| --- | --- |
| 8 | –280 kJ mol−1 |
| 9 | If less energy is needed to break bonds than is released in making new bonds, then a reaction is exothermic overall |
| 10 | Al + 3Ag+→ Al3+ + 3Ag |

|  |  |
| --- | --- |
| 11 | Reduction \_\_ – occurs at the positive electrode4H+ + O2 + 4e− → 2H2O is \_\_ – an example of a reduction reactionOxidation is the \_\_ – loss of electronsHydrogen atoms form hydrogen ions \_\_ – at the negative electrode |
| 12 | Mg 🡪 Mg2+ + 2e− – OxidationCa2+ + 2e−🡪 Ca – ReductionHCl + NaOH 🡪 NaCl + H2O – NeutralisationMg + Zn2+→ Mg2+ + Zn – Displacement |

|  |  |
| --- | --- |
| 13 | Oxidation is loss of electrons: Reduction is gain of electrons: Reaction shows oxidation |
| 14 | 368 + (6 × 412) + (7 × 498) = 6326 kJ mol−1: 4 × (532 + 532) + (6 × (465 + 465)) = 9836 kJ mol−1: 6326 − 9836 = −3510 kJ mol−1 |