Dr Clays A-level Chemistry

Paper 1 Physical Chemistry

Multiple Choice

QUESTIONS

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Q1. There are 392 mol of pure gold in a bar measuring 10 cm by 10 cm by 40 cm. What is the density of gold in kg dm^{-3}?

A 193

B 19.3

C 1.93

D 0.193

(Total 1 mark)

**Q2.** Ions of two isotopes of iron are

$$^{53}Fe^{2+} \qquad ^{56}Fe^{2+}$$

Which statement is correct?

A The ions of both the isotopes have the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

B The ions of both the isotopes contains 26 neutrons

C $^{53}Fe^{2+}$ has fewer protons than $^{56}Fe^{2+}$

D After acceleration to the same kinetic energy $^{56}Fe^{2+}$ will move more slowly than $^{53}Fe^{2+}$

(Total 1 mark)

**Q3.** Refer to the unbalanced equation below when answering this question.

$$K_2Cr_2O7 + 3H_2C_2O_4 + \_H_2SO_4 \longrightarrow Cr_2(SO_4)_3 + \_H_2O + 6CO_2 + K_2SO_4$$
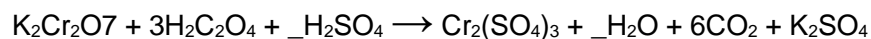
In the balanced equation the mole ratio for sulfuric acid to water is

A 1 : 4

B 1 : 2

C 4 : 7

D 4 : 9

(Total 1 mark)

Q4. Which species contains an element with an oxidation state of +4?

A NO_2^+ ☐

B ClO_3^- ☐

C H_2SO_3 ☐

D PCl_5 ☐

(Total 1 mark)

Q5. Refer to the unbalanced equation below when answering this question.

$$K_2Cr_2O7 + 3H_2C_2O_4 + \_H_2SO_4 \longrightarrow Cr_2(SO_4)_3 + \_H_2O + 6CO_2 + K_2SO_4$$
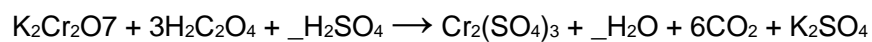
What is the reducing agent in this reaction?

A H^+ ☐

B $C_2O_4^{2-}$ ☐

C K^+ ☐

D $Cr_2O_7^{2-}$ ☐

(Total 1 mark)

Q6. Which substance exists as a macromolecule?

A Cu ☐

B SiO_2 ☐

C P_4O_{10} ☐

D MgO ☐

(Total 1 mark)

Q7. Which compound has the highest boiling point?

A C_2H_4

B C_2H_6

C CH_3NH_2

D CH_3F

(Total 1 mark)

Q8. Which molecule has the largest dipole?

A ClF_3

B BF_3

C SF_6

D CF_4

(Total 1 mark)

Q9. The successive ionisation energies for element X are shown in the following graph.
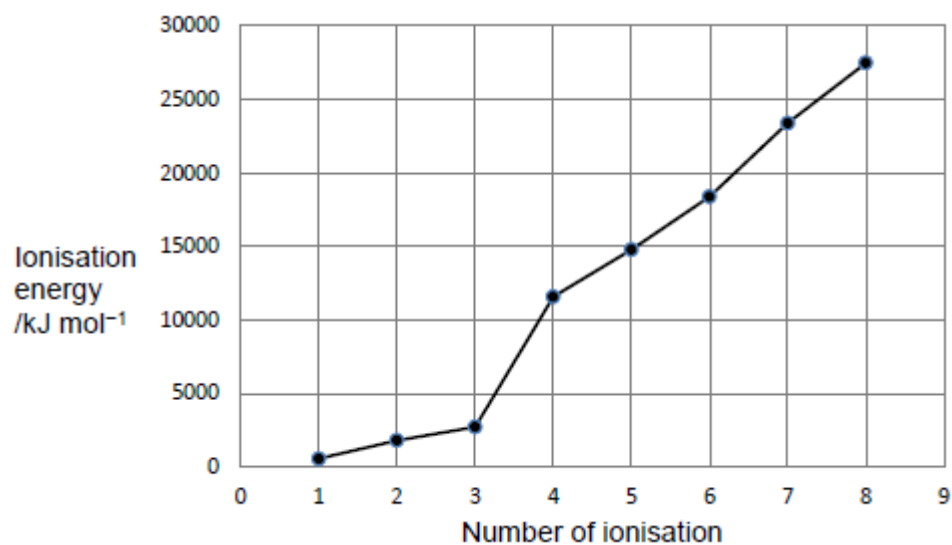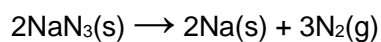

Which element is X?

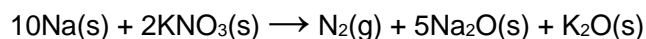Paper 1 Physical Chemistry Multiple Choice Questions

A Nitrogen ⬭

B Phosphorus ⬭

C Aluminium ⬭

D Boron ⬭

(Total 1 mark)

Q10. In a car airbag, sodium azide (NaN_3) decomposes to form sodium metal and nitrogen gas.

$$2NaN_3(s) \longrightarrow 2Na(s) + 3N_2(g)$$

The sodium metal then reacts with potassium nitrate to produce more nitrogen gas.

$$10Na(s) + 2KNO_3(s) \longrightarrow N_2(g) + 5Na_2O(s) + K_2O(s)$$

If 2.00 mol of sodium azide react in this way, how many molecules of N_2 will be formed?
(The Avogadro constant $L = 6.022 \times 10^{23}$ mol^{-1})

A 2.41×10^{24} ⬭

B 1.93×10^{24} ⬭

C 1.81×10^{24} ⬭

D 9.63×10^{23} ⬭

(Total 1 mark)

Q11. Which of the following solutions would react exactly with a solution containing 0.0500 mol sulfuric acid?

A 50.0 cm^3 of 1.00 mol dm^{-3} KOH ⬭

B 100.0 cm^3 of 2.00 mol dm^{-3} KOH ⬭

C 100.0 cm^3 of 2.00 mol dm^{-3} $Ba(OH)_2$ ⬭

D 50.0 cm^3 of 1.00 mol dm^{-3} $Ba(OH)_2$ ⬭

(Total 1 mark)

Q12. The M_r of hydrated copper sulfate ($CuSO_4.5H_2O$) is 249.6.

Which of the following is the mass of hydrated copper sulfate required to make 50.0 cm^3 of a 0.400 mol dm^{-3} solution?

A 3.19 g

B 3.55 g

C 3.71 g

D 4.99 g

(Total 1 mark)

Q13. 30 cm^3 of xenon are mixed with 20 cm^3 of fluorine. The gases react according to the following equation. Assume that the temperature and pressure remain constant.

$$Xe(g) + F_2(g) \rightarrow XeF_2(g)$$
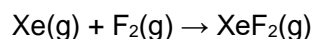
What is the final volume of gas after the reaction is complete?

A 50 cm^3

B 40 cm^3

C 30 cm^3

D 20 cm^3

(Total 1 mark)

Q14. Propene can be made by the dehydration of propan-2-ol.

What is the percentage yield when 30 g of propene (M_r = 42.0) are formed from 50 g of propan-2-ol (M_r = 60.0)?

A 60%

B 67%

C 81%

D 86%

(Total 1 mark)

Q15. Which of these pieces of apparatus has the lowest percentage uncertainty in the measurement shown?

A Volume of 25 cm³ measured with a burette with an uncertainty of ±0.1 cm³.

B Volume of 25 cm³ measured with a measuring cylinder with an uncertainty of ±0.5 cm³.

C Mass of 0.150 g measured with a balance with an uncertainty of ±0.001 g.

D Temperature change of 23.2 °C measured with a thermometer with an uncertainty of ±0.1 °C.

(Total 1 mark)

Q16. **A** and **B** react together in this reversible reaction.

$$A \ + \ 3B \ \rightleftharpoons \ C \ + \ 2D$$
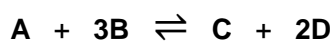
A mixture of 10 mol of **A** and 10 mol of **B** were left to reach equilibrium. The equilibrium mixture contained 4 mol of **B**.

What is the total amount, in moles, of substances in the equilibrium mixture?
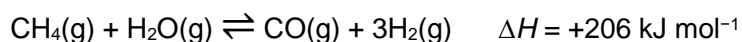
A 14

B 16

C 18

D 20

(Total 1 mark)

Q17. Hydrogen is produced by the reaction of methane with steam. The reaction mixture reaches a state of dynamic equilibrium.

Paper 1 Physcical Chemistry Multiple Choice Questions

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +206 \text{ kJ mol}^{-1}$$

Which of the following shows how the equilibrium yield of hydrogen and the value of the equilibrium constant are affected by the changes shown?

Change	Effect on equilibrium yield of $H_2(g)$	Effect on value of K_c	
A Increase pressure	decrease	decrease	○
B Add a catalyst	increase	no effect	○
C Increase temperature	increase	increase	○
D Remove CO(g) as formed	increase	increase	○

(Total 1 mark)

Q18. A pale brown mixture of NO_2 and N_2O_4 is allowed to reach equilibrium in a sealed gas syringe according to the following equation.

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$
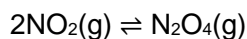
When the plunger is pushed further into the syringe the pressure increases and the mixture becomes paler in colour.

When the syringe is placed in a hot oven the mixture becomes darker in colour.

Which of the following statements is correct?

A NO_2 is brown and the forward reaction is exothermic. ○

B NO_2 is brown and the forward reaction is endothermic. ○

C NO_2 is colourless and the forward reaction is exothermic. ○

D NO_2 is colourless and the forward reaction is endothermic. ○

(Total 1 mark)

Q19. The table below shows data for the four hydrocarbons ethyne, propyne, propene and propane. ΔHc is the standard enthalpy of combustion of these hydrocarbons.

Compound	Name	M_r	$-\Delta Hc^{\ominus}$ / kJ mol^{-1}

| HC≡CH	ethyne	26	1300
HC≡CCH$_3$	propyne	40	1940
H$_2$C=CHCH$_3$	propene	42	2060
CH$_3$CH$_2$CH$_3$	propane	44	2220

The complete combustion of 2.0 g of one of the above hydrocarbons releases exactly 100 kJ of heat energy.

This hydrocarbon is

A   ethyne

B   propyne

C   propene

D   propane

(Total 1 mark)

Q20. Hydrogen is produced by the reaction of methane with steam. The reaction mixture reaches a state of dynamic equilibrium.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +206 \text{ kJ mol}^{-1}$$
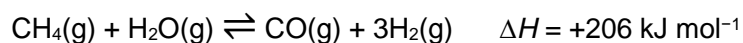
Some enthalpy data is given in the table.

Bond	C–H	O–H	H–H	C≡H
Bond enthalpy / kJ mol^{-1}	413	463	436	To be calculated

Use the information in the table and the stated enthalpy change to calculate the missing bond enthalpy.

A 234

B 1064

C 1476

D 1936

(Total 1 mark)

Paper 1 Physcical Chemistry Multiple Choice Questions

Q21. In which one of the following reactions is there a decrease in entropy?

A $[Fe(H_2O)_6]^{3+}(aq) + 3C_2O_4^{2-}(aq) \rightarrow [Fe(C_2O_4)_3]^{3-}(aq) + 6H_2O(l)$

B $[Cu(H_2O)_6]^{2+}(aq) + EDTA^{4-}(aq) \rightarrow [Cu(EDTA)]^{2-}(aq) + 6H_2O(l)$

C $[CoCl_4]^{2-}(aq) + 6H_2O(l) \rightarrow [Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq)$

D $Na_2CO_3(s) + 2H^+(aq) \rightarrow 2Na^+(aq) + CO_2(g) + H_2O(l)$

(Total 1 mark)

Q22. Which one of the following has the most covalent character?

A MgF_2

B $MgBr_2$

C AlF_3

D $AlBr_3$

(Total 1 mark)

Q23. Which one of the following best explains why the lattice enthalpy of magnesium chloride is much larger than that of lithium chloride?

A Magnesium has a greater electronegativity than lithium.

B Magnesium ions have a greater polarising power than lithium ions.

C Magnesium ions have a greater ionic radius than lithium ions.

D Magnesium ions have a greater charge than lithium ions.

(Total 1 mark)

Q24. Using the information below, answer this question.

$Fe_2O_3(s) + 3H_2(g) \rightarrow 2Fe(s) + 3H_2O(g)$ $\Delta H^{\ominus} = +96$ kJ mol^{-1}, $\Delta S^{\ominus} = +138$ J K^{-1} mol^{-1}
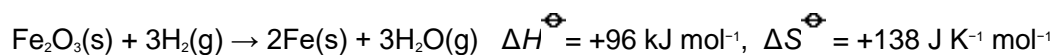
	Fe₂O₃(s)	H₂(g)	Fe(s)

Paper 1 Physcical Chemistry Multiple Choice Questions

$\Delta H_f^{\ominus}$ / kJ mol⁻¹	−822.0	0	0
$\Delta S^{\ominus}$ / J K⁻¹ mol⁻¹	90.0	131.0	27.0

The standard entropy value for steam is

A   +332 J K⁻¹ mol⁻¹

B   +189 J K⁻¹ mol⁻¹

C   +145 J K⁻¹ mol⁻¹

D   +85 J K⁻¹ mol⁻¹

(Total 1 mark)

Q25. Which one of the equations below represents a reaction that is feasible at all temperatures?

A $P(s) \rightarrow Q(s) + R(g)$ endothermic

B $2L(g) + M(g) \rightarrow 2N(g)$ exothermic

C $S(g) \rightarrow 2T(g)$ exothermic

D $A(g) + B(g) \rightarrow C(g)$ endothermic

(Total 1 mark)

Q26. The following cell has an EMF of +0.46 V.

$$Cu \mid Cu^{2+} \mid\mid Ag^+ \mid Ag$$

Which statement is correct about the operation of the cell?

A   Metallic copper is oxidised by Ag⁺ ions.

B   The silver electrode has a negative polarity.

C   The silver electrode gradually dissolves to form Ag⁺ ions.

D   Electrons flow from the silver electrode to the copper electrode via an external circuit.

(Total 1 mark)

Q27. In this question consider the data below.

$$E^{\ominus} / V$$

$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	−0.13

The e.m.f. of the cell $Pt(s) \mid H_2(g) \mid H^+(aq) \parallel Ag^+(aq) \mid Ag(s)$ would be increased by

A   increasing the concentration of $H^+(aq)$.

B   increasing the surface area of the Pt electrode.

C   increasing the concentration of $Ag^+(aq)$.

D   decreasing the pressure of $H_2(g)$.

(Total 1 mark)

Q28. Use the data in the table below to answer this question.

$$E^{\ominus} / V$$

$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$	+ 1.52
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$	+ 1.33
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+ 0.77
$Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(aq)$	− 0.41
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	− 0.76

Which one of the following statements is **not** correct?

A $Fe^{2+}(aq)$ can reduce acidified $MnO_4^-(aq)$ to $Mn^{2+}(aq)$

B $CrO_7^{2-}(aq)$ can oxidise acidified $Fe^{2+}(aq)$ to $Fe^{3+}(aq)$

C $Zn(s)$ can reduce acidified $Cr_2O_7^{2-}(aq)$ to $Cr^{2+}(aq)$

D $Fe^{2+}(aq)$ can reduce acidified $Cr^{3+}(aq)$ to $Cr^{2+}(aq)$

(Total 1 mark)

Q29.

$$Cr_2O_7^{2-} (aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l) \qquad E^{\ominus} = +1.33 \text{ V}$$

$$Br_2(aq) + 2e^- \rightarrow 2Br^-(aq) \qquad E^{\ominus} = +1.09 \text{ V}$$

$$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq) \qquad E^{\ominus} = +0.77 \text{ V}$$

$$VO^{2+}(aq) + 2H^+(aq) + e^- \rightarrow V^{3+}(aq) + H_2O(l) \qquad E^{\ominus} = +0.34 \text{ V}$$

$$SO_4^{2-} (aq) + 4H^+(aq) + 2e^- \rightarrow H_2SO_3(aq) + H_2O(l) \qquad E^{\ominus} = +0.17 \text{ V}$$
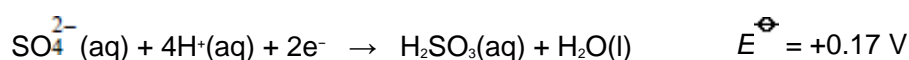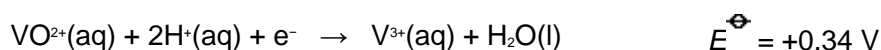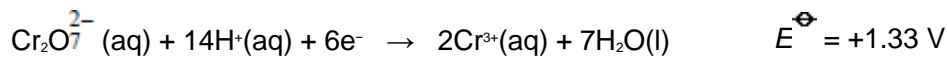
Based on the above data, which one of the following could reduce 0.012 mol of bromine to bromide ions?

A 40 cm³ of a 0.10 mol dm⁻³ solution of $Cr_2O_7^{2-}$ (aq)

B 80 cm³ of a 0.30 mol dm⁻³ solution of Fe^{3+}(aq)

C 50 cm³ of a 0.24 mol dm⁻³ solution of V^{3+}(aq)

C 50 cm³ of a 0.24 mol dm⁻³ solution of H_2SO_3(aq)

(Total 1 mark)

Q30. In this question consider the data below.

	$E^{\ominus}$ / V
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	−0.13

The e.m.f. of the cell $Ag(s) \mid Ag^+(aq) \parallel Pb^{2+}(aq) \mid Pb(s)$ is

A 0.93 V

B 0.67 V

C −0.67 V

D −0.93 V

(Total 1 mark)

Q31. Refer to the following reaction

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H^{\ominus} = -11 \text{ kJ mol}^{-1}, \qquad \Delta S^{\ominus} = +20 \text{ J K}^{-1} \text{ mol}^{-1}$$
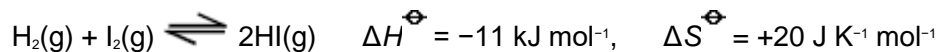
Which one of the following statements is correct?

A   This is a redox reaction.

B   The reaction is **not** feasible below 298 K

C   At equilibrium, the yield of hydrogen iodide is changed by increasing the pressure.

D   At equilibrium, the yield of hydrogen iodide increases as the temperature is increased.

(Total 1 mark)

Q32. This question is based on the reactions and compounds shown in the scheme below.
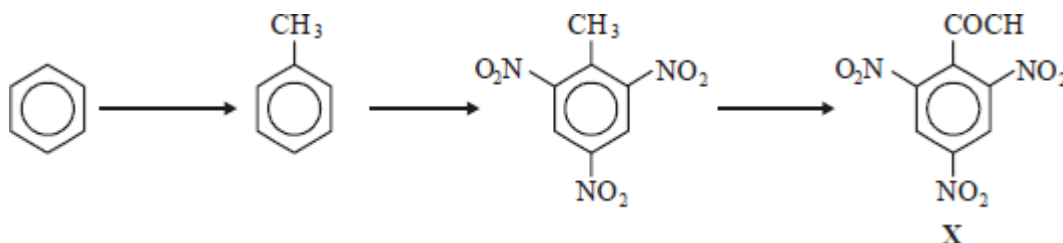
A 0.100 mol dm^{-3} solution of **X** is found to have a pH of 2.50. The value of K_a in mol dm^{-3} is

A 3.16×10^{-2}

B 3.16×10^{-3}

C 1.00×10^{-4}

D 1.00×10^{-5}

(Total 1 mark)

Q33. A solution of sodium ethanoate has a pH of 8.91 at 25 °C. The hydrogen ion and hydroxide ion concentrations in this solution are

A $[H^+] = 1.00 \times 10^{-9}$ mol dm^{-3} $[OH^-] = 1.00 \times 10^{-5}$ mol dm^{-3}

B $[H^+] = 1.00 \times 10^{-9}$ mol dm^{-3} $[OH^-] = 8.13 \times 10^{-6}$ mol dm^{-3}

C $[H^+] = 1.23 \times 10^{-9}$ mol dm^{-3} $[OH^-] = 1.00 \times 10^{-5}$ mol dm^{-3}

D $[H^+] = 1.23 \times 10^{-9}$ mol dm^{-3} $[OH^-] = 8.13 \times 10^{-6}$ mol dm^{-3}

(Total 1 mark)

Q34. Use the information below to answer this question.

A saturated solution of magnesium hydroxide, $Mg(OH)_2$, contains 0.1166 g of $Mg(OH)_2$ in 10.00 dm^3 of solution. In this solution the magnesium hydroxide is fully dissociated into ions.

Which one of the following is the pH of a solution of magnesium hydroxide containing 4.0×10^{-5} mol dm^{-3} of hydroxide ions at 298 K?
($K_w = 1.0 \times 10^{-14}$ mol^2 dm^{-6} at 298 K)

A   9.6

B   9.5

C   8.6

D   8.3

(Total 1 mark)

Q35. The acid dissociation constant, K_a, of a weak acid HA has the value 2.56×10^{-4} mol dm^{-3}.

What is the pH of a 4.25×10^{-3} mol dm^{-3} solution of HA?

A   5.96

B   3.59

C   2.98

D   2.37

(Total 1 mark)

Paper 1 Physcical Chemistry Multiple Choice Questions

Q36. What is the pH of a 0.020 mol dm^{-3} solution of a diprotic acid which is completely dissociated?

A   1.00   ⬭

B   1.40   ⬭

C   1.70   ⬭

D   4.00   ⬭

(Total 1 mark)