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| **1.** | (a) | Electrophile: electron pair acceptor (M1), Nucleophile: electron pair donor (M2) |
|  | (b) | C=C in alkenes is an area of high electron density (M3), C-X bond in haloalkanes is polar; C is partially positive (M4), electron pair in π-bond can be donated to electrophiles OR C in C-X can accept electron pair from nucleophiles (M5)  [5] |
| **2.** | (a) | Curly arrow from C=C bond to H in H-Br and polarity on H-Br shown (δ+, δ-) (M1), correct carbocation drawn [CH(CH3)(C2H5)]+ (M2), curly arrow from lone pair on Br- towards C+ (M3) |
|  | (b) | 1-bromobutane formed via carbocation [CH2CH2C2H5]+ (M4), [CH2CH2C2H5]+ is primary; [CH(CH3)(C2H5)]+ is secondary (M5), Secondary carbocations are more stable than primary carbocations (M6)  [max 5] |
| **3.** | (a) | Curly arrow from long pair on N in NH3 to C and polarity on C-Cl shown (δ+, δ-) (M1), Curly arrow from C-Cl bond to Cl shown simultaneously (M2), + on N and curly arrow from N-H to H (M3), aminoethane or ethylamine (M4) |
|  | (b) | Curly arrow from C-Br to Br and polarity on C-Br shown (δ+, δ-) (M5), correct carbocation drawn [C(CH3)3]+ (M6), curly arrow from lone pair on C in CN- to C+ (M7), dimethylpropanenitrile (M8)  [max 5] |
| **4.** | (a) | Change [OH-] and monitor rate of reaction (M1), if changing [OH-] changes rate of reaction then mechanism is SN2 (ORA) (M2); monitor optical activity of product (M3), if product is optically active then mechanism is SN2 (ORA) (M4) |
|  | (b) | Reaction faster with 2-bromobutane (ORA) (M5), C-Br bond weaker than C-Cl bond (ORA) (M6)  [max 5] |
| **5.** | (a) | C3H7I + OH- 🡪 C3H6 + H2O + I- (M1)  Curly arrows from C-H to C-C (M2), correct dipole on C-I shown and curly arrow from C-I to I (M3) |
|  | (b) | Use of ethanol rather than water as solvent (M4), Higher temperature OR distillation rather than reflux (M5) |
|  | (c) | nucleophile in substitution, base in elimination (M6)  [max 5] |
| **6.** | (a) | Curly arrow from lone pair on O in -OH to H+ to form protonated -OH group (M1), Curly arrows from C-H bond to C-C bond and from C-O bond to O (M2), H+ acts as a catalyst (M3) |
|  | (b) | Cis or E-pent-2-ene and correct structure (M4), trans or Z-pent-2-ene and correct structure (M5)  [5] |
| **7.** | (a) | CH4 + Cl2 🡪 CH3Cl + HCl (M1) |
|  | (b) | CH4 + Cl 🡪 CH3 + HCl (M2), CH3 + Cl2 🡪 CH3Cl + Cl (M3), UV light causes homolytic fission of Cl-Cl bond (M4) |
|  | (c) | CH3 + CH3 🡪 C2H6 (M5)  [5] |
| **8.** | (a) | C3H8 + 2Cl2 🡪 C3H6Cl2 + 2HCl (M1) |
|  | (b) | 1,1-dichloropropane and correct structure (M2), 1,2-dichloropropane and correct structure (M3),  1,3-dichloropropane and correct structure (M4), 2,2-dichloropropane and correct structure (M5)  [5] |
| **9.** | (a) | Homolytic fission: covalent bond breaks and one electron moves to each atom, eg Cl-Cl 🡪 2Cl; heterolytic fission: covalent bond breaks and both electrons move to one atom, eg Cl2 🡪 Cl+ + Cl- (M1, M2, M3 max 3) |
|  | (b) | Transition state: state of maximum energy through which reactants must pass to form products,  eg Cl—CH2—OH in SN2; intermediate: species formed during a chemical reaction after one or more steps but not present in the final mixture, eg any carbocation during electrophilic addition or SN1 (M4, M5, M6 max 3)  [max 5] |