Amateur radio syllabus - Intermediate level

Ref	Q#	

Section 1 – Licensing conditions and station identification

1A Nature of amateur radio, types of licence and call signs

1A4	1	Recall the conditions related to Variation to and Revocation of Amateur Licences; i.e. failure to advise change of name, address and confirmation of licensee details.

1B Operators and supervision

1B1	1	Recall that an Intermediate Licensee may operate the Radio Equipment of any other UK licensed amateur under that person's direct supervision using the supervisor's call sign, and obeying the terms of the supervisor's licence. Understand the meaning of direct supervision, duties of the supervisor and need for the operator to comply with the licence. *Note: The term 'Radio Equipment' (in initial capitals) is a defined licence term meaning the equipment used and identified by the operator's call sign. If a visiting amateur uses the radio equipment with his own call sign, it is his/her Radio Equipment.*
1B2	1	Recall that an Intermediate Licensee may (with permission) use another amateur's Radio Equipment unsupervised, but using the call sign and conditions of his or her own licence. Recall that it is then regarded as his/her Radio Equipment because his/her call sign has been given in identification. *Note: The term 'Radio Equipment' (in initial capitals) is a defined licence term meaning the equipment used and identified by the operator's call sign. If a visiting amateur uses the radio equipment with his call sign, it is his/her Radio Equipment.*

1C Messages

1C1	2	Recall that in an International disaster messages may be passed, internationally, on behalf of non-licensed persons. Recall that non-amateur stations involved in international disaster communications may also be heard on amateur frequencies.
1C2	2	Recall that the licensee may pass messages on behalf of a User Service and may permit a member of the User Service to use the Radio Equipment to send messages. Recall the identity of the User Services. Recall that, except under the direction of a member of a User Service who may obscure the message to retain confidentiality, all transmissions must be in plain language. *Note: It is only necessary to remember the User Services named in the licence and that the Police, Fire, Ambulance and Coastguard are included in the 'Category 1 and 2 responders' along with local government.*

Ref	Q#	
1D		**Apparatus, inspection and closedown**
1D1	3	Recall that transmissions from the station must not cause Undue Interference to other radio users. Recall that the Licensee must reduce any emissions causing interference, to the satisfaction of a person authorised by Ofcom. Understand that this may include a reduction in transmit power or any other action required to reduce emissions to an acceptable level.
1D2	3	Recall the occasions for mandatory log keeping. Understand circumstances in which modification or cessation of operating of the station may be required. Understand circumstances in which modification of transmitting equipment may be required.
1E		**Unattended and remote control operation**
1E1	4	Recall that the licensee may conduct unattended operation of a Beacon, for the purposes of direction-finding competitions, or for digital communications provided operation is consistent with the terms of the Licence. Recall that unattended operation does not include providing for general use by other amateurs.
1E2	4	Recall that the licensee may conduct Remote Control operation of the main station in a manner consistent with the terms the Licence. Recall that the Remote Control link must be by radio in an amateur band, limited to 500mW pep e.r.p. maximum transmit power. Recall that the Remote Control link should be above 30MHz. Recall that the Remote Control link must be failsafe to avoid unintended transmissions and adequately secure to ensure the station remains compliant with the terms of the Licence. Recall that Remote Control operation does not include providing for general use by other amateurs.
1F		**CEPT and international**
1F1	5	Recall that other Administrations (foreign countries) do not routinely recognise the Intermediate Licence.
1G		**Licence schedule**
1G1	6	(LF, MF and HF) Identify relevant information in the schedule to the Intermediate licence. *A copy of the schedule will be available during the examination.*
1G2	6	(VHF, UHF, SHF and EHF) Identify relevant information in the schedule to the Intermediate licence. *A copy of the schedule will be available during the examination.*

Ref	Q#	

Section 2 – Technical aspects

2A Fundamental theory

2A1	7	Recall that components have tolerances, and that the measured value of a component may not precisely agree with its marked value.

2C Resistance

2C1	7	Understand circuits comprising series and parallel connections of resistors and cells. Calculate the value of any one of the three quantities (V, I or R) given the other two. Calculate the combined resistance of two or three resistors in series and/or parallel. *Resistors of different values may be used in series or parallel or combined series parallel circuits.* *The formula for parallel resistors will be provided.* *The prefixes milli and kilo may be involved for some of these calculations.*
2C2	8	Understand that two or three resistors can be arranged to act as a potential divider and apply the formula. *The formula for resistors in a potential divider will be provided.* *The prefixes milli and kilo may be involved for some of these calculations.*
2C3	8	Understand the difference between potential difference (PD) and electromotive force (EMF) Understand the concept of source resistance (impedance) and voltage drop due to current flow.

2D Reactive components

2D1	9	Recall that a capacitor normally consists of two metal plates separated by an insulating material and that its capacitance is measured in Farads. Understand that a capacitor can store an electric charge, and that its ability to store a charge (capacitance) depends upon the area of the plates, their separation and the nature of the material between the plates (the dielectric).
2D2	9	Understand and apply the formulae for calculating the combined values of two or three capacitors in series and in parallel.
2D3	9	Recall that some capacitors eg electrolytic are polarised and must be correctly connected to avoid injury, damage or destruction.

Ref	Q#	
2D4	10	Understand the relative movement of a conductor in a magnetic field will induce a voltage across the ends of the conductor. Recall that a current passing through a wire forms a magnetic field around the wire. Recall that an inductor is normally a coil formed of a number of turns of wire to concentrate the magnetic field and that inductance is measured in Henries. Recall that an inductor is able to store energy in its magnetic field. Recall that the ability to store energy is known as inductance, which depends upon the number of turns of wire on the coil and its dimensions.
2D5	10	Understand and apply the formulae for calculating the combined values of two or three inductors in series and in parallel.
2D6	10	Recall that the inductance of a coil increases with increasing number of turns, increasing coil diameter and decreasing spacing between turns. Understand the use of high permeability cores and slug tuning.
2E		**AC theory**
2E1	11	Understand that by repeatedly charging and discharging in alternate directions, a capacitor can pass alternating currents, but cannot pass a direct current.
2E2	11	Understand the sinusoidal curve as a graphical representation of the rise and fall of an alternating current or voltage over time and that both the frequency and the amplitude must be specified. Recognise the graphical representation of a square wave. Recall that the time in seconds for one cycle is the Periodic Time (T) and the formula T=1/f and f= 1/T where f = frequency in Hertz and T = time interval in seconds. Recall the concept of phase difference between two signals, and that it can be expressed in degrees.
2E3	11	Recall that the potential difference across and current through a resistor are in phase. Recall that the power dissipated in a resistive circuit varies over the cycle. Recall that the RMS current or voltage in an AC circuit is equal to the current or voltage of a DC supply that would result in the same power dissipation. Recall that the RMS value of a sinusoidal waveform, Vrms = 0.707×Vp (peak Voltage). Perform relevant calculations. Recall that the term ‘Reactance’ describes the opposition to current flow in a purely inductive or capacitive circuit where the phase difference between V and I is 90°.
2E4	12	Recall that the ratio of the RMS potential difference to the RMS current as the capacitor stores energy in its electric field is called the reactance of the capacitor and is measured in ohms. Understand that the reactance of a capacitor depends on the frequency of the alternating current and that the reactance falls as the frequency rises. Identify the graph of reactance against frequency for the capacitor.

Ref	Q#	
2E5	12	Recall that an inductor will take time to store or release energy in its magnetic field. Recall that the ratio of the RMS potential difference to the RMS current as the inductor stores energy in its magnetic field is called the reactance of the inductor and is measured in ohms. Understand that the reactance of an inductor depends on the frequency of the alternating current and that the reactance rises as the frequency rises. Identify the graph of reactance against frequency for the inductor.
2E6	12	Recall that in a circuit comprising resistors and capacitors or inductors (or both) a current will result in energy transfer into heat in the resistors and energy storage and release in the capacitors or inductors. Recall that in such a circuit the ratio of the overall potential difference to current is termed 'impedance' and that this name denotes an opposition to both energy transfer and energy storage in the circuit. Recall impedance is measured in ohms. *Note: Phase and vector notation is NOT included at this level.*
2E7	13	Recall and manipulate the formula $v = f \times \lambda$ Calculate frequency or wavelength given the other parameter. *The velocity of radio waves will be given in the Reference Booklet.*
2E8	13	Understand that where a conductor is carrying an RF signal which has a wavelength comparable to the length of the conductor that the magnitude and direction of the current and voltage at any point in time will vary in a sinusoidal manner along the length of the conductor.

2F Digital signals

2F1	14	Recall that digital signals with more bits and/or increased sampling rate enables a more accurate representation of the analogue signal. Recall that the error introduced by sampling the analogue signal to produce the digital signal is a form of distortion. Recall that the minimum sampling rate needs to be greater than twice the frequency of the analogue signal to adequately capture the detail of the analogue signal being sampled. Recall that the minimum sampling rate is known as the Nyquist rate.

Ref	Q#	
2G		**Transformers**
2G1	15	Understand that a simple transformer consists of two coils of wire sharing the same magnetic field. Recall that it may have an iron core to concentrate the field. Understand that at higher frequencies (e.g. RF and IF) a ferrite core, rather than an iron core, is used for improved efficiency. Understand that energy is transferred from one coil to the other by changes in the field when alternating current is used, and that this does not happen with constant direct current. Understand that an alternating potential difference (such as the mains) can be stepped down using fewer turns of wire on the secondary coil than the primary and can be stepped up using more turns on the secondary than on the primary. Understand that the output from a transformer will always be an alternating current. *Note: Appreciation of the impedance change is not required.*
2H		**Tuned circuits and resonance**
2H1	16	Recall that a series or parallel circuit of a capacitor and inductor together forms a tuned circuit. Recall, using graphical methods, that at resonance the reactance of the capacitance will equal the reactance of the inductance, $X_C = X_L$.
2H2	16	Recall that, at their resonant frequencies, series tuned circuits present a low impedance, whereas parallel tuned circuits present a high impedance. Identify the response curves of impedance vs frequency for series and parallel resonant circuits.
2H3	16	Recall that the energy stored in the capacitor and inductor in a tuned circuit can transfer from one to the other at a particular frequency, known as the resonant frequency. Recall how the resonant frequency depends on the value of capacitance and inductance. *Note that candidates must know that increasing L or C reduces the resonant frequency and vice-versa. Knowledge of the resonant frequency formula is not required.*
2H4	16	Recall that selectivity of a tuned circuit is the ratio of the bandwidth of the circuit (that is the range of frequencies the circuit will accept) to the resonant frequency. Recall that the Q factor of a tuned circuit is an indication of the selectivity of the tuned circuit.
2H5	16	Identify the circuits of simple low pass, high pass, band pass and band stop (notch) filters and their response curves. Recall, using graphical methods, the concept of the cut-off frequency.

	Ref	Q#	
2I			**Semiconductor devices**
	2I1	17	Recall that a diode will conduct current in one direction only. Recall that a diode junction has a depletion layer and that a voltage must be applied to overcome this and allow current to flow (forward bias). Understand the use of a diode to produce direct current from an alternating current is known as rectification.
	2I2	17	Recall that a variable capacitance diode behaves like a capacitor when reverse biased and that the capacitance of a reverse biased diode depends on the magnitude of the reverse bias.
	2I3	17	Understand that a bipolar junction transistor is a three terminal device (emitter, base, collector) in which a small base current will control a larger collector current and this enables the transistor to be used as an amplifier. Understand that the ratio of the collector current to the base current (I_C/I_B) is the current gain β or h_{FE} of the transistor. Understand that if the variation in the base current is large enough the collector current can be turned on and off and the transistor behaves as a switch. *Note: It is not required to recall transistor configurations. Circuits shown will use an NPN transistor connected in common emitter mode.*
	2I4	18	Recognise the circuit of a simple common emitter amplifier. Calculate the value of the collector resistor to set the collector voltage midway between V supply and 0V given the base current and transistor gain β. Recall that semiconductors must be provided with the correct DC voltages and currents to allow them to function and that this is termed biasing. Understand in simple terms how a (current) signal at the base causes a larger current signal at the collector and resulting change in instantaneous collector voltage.
	2I5	18	Recall that a transistor can be used to generate audio and radio frequencies by maintaining the oscillations in a tuned or frequency selective circuit. Distinguish between a crystal oscillator and a variable frequency oscillator (VFO) based on a tuned circuit. *Diagrams will show the Colpitts oscillator with the transistor in emitter follower mode. Candidates are not expected to recognise other types of oscillator.*
	2I6	20	Recall that many individual semiconductor devices may be built on a common substrate and packaged as an integrated circuit (IC). Recall that ICs may provide complete circuit functions, including, amplifiers, oscillators, voltage regulators and digital processing chips in a single package. *Questions will be limited to the IC applications shown above.*

Ref	Q#	
2J		**Cells and power supplies**
2J1	19	Recall that different technologies used in cells give different terminal voltages. Recall that battery capacity (stored energy) is measured in Ampere-hours (Ah).
2J2	19	Recall the circuit diagrams and characteristics of different types of rectifier and smoothing circuits (i.e. half wave, full wave and bridge).
2J3	19	Understand that in a rectifier circuit a capacitor can store a charge during the conducting part of the cycle and release it during the non-conducting part, providing a smoothing effect and a smoother DC output. Identify the AC and rectified (pulsed DC) waveforms.
2J4	20	Identify discrete component and integrated circuit linear power supplies and understand the basic principle of their operation. Recall the relative merits of linear and switched mode power supplies: size, efficiency, heat, input and output voltage, RFI, cost and weight.

Section 3 – Transmitters and receivers

3A		**Transmitter concepts**
3A2	21	Recall the meaning of depth of modulation for amplitude modulation. Recall the meanings of wide band and narrow band frequency modulation. Recall the meaning of the term Peak Deviation.
3A3	21	Understand that single sideband (SSB) is a form of amplitude modulation where one sideband and the carrier have been removed from the transmitted signal. Understand that SSB is more efficient than AM or FM because power is not used to transmit the carrier and the other sideband. Understand that a second advantage is that the transmitted signal takes up only half the bandwidth, e.g. 3kHz not 6kHz. Recall that : • AM uses less bandwidth than FM • SSB uses less bandwidth than AM • CW uses less bandwidth than SSB. • Digital modes may use less bandwidth than any of the above.
3B		**Transmitter architecture**
3B1	21	Understand the block diagrams of CW, AM, SSB and FM transmitters.

Ref	Q#	
3C		**Oscillators**
3C1	21	Recall and understand the relative advantages and disadvantages of a crystal oscillator and a VFO. Recall that the resonant frequency of the tuned circuit in a VFO determines the frequency of oscillation.
3C2	21	Recall that the frequency stability of an oscillator can be improved by rigid mechanical construction, screening the oscillator enclosure, a regulated DC supply and a buffer amplifier immediately after the oscillator circuit. Understand that a lack of stability (drift) may result in operation outside the amateur bands. Recall that most modern oscillators are digital synthesisers, which are very stable and are based on a crystal reference.
3C3	21	Recall that digital signals can be used to generate audio and RF signals by Direct Digital Synthesis (DDS). Recall the meaning of DDS. Recall that a Direct Digital Synthesiser generates audio and RF signals from pre-set digital values held in a memory, or Lookup Table.
3E		**Microphone amplifiers and modulators**
3E1	22	Recall that a Balanced Modulator is used to produce two sidebands whilst suppressing the carrier.
3E2	22	Understand that an SSB filter is a Band Pass Filter that will only allow one sideband to pass to the Power Amplifier. Recall that in an analogue transmitter, SSB filters are normally constructed from a number of quartz crystals or other resonators.
3E3	22	Recall that a variable capacitance diode can be used in an oscillator to produce frequency modulation (FM).
3F		**RF power amplifiers**
3F1	22	Understand the concept of the efficiency of an amplifier stage and estimate expected RF output power for a given DC input power, given the stage's efficiency.
3G		**Transmitter interference**
3G2	23	Recall that oscillators, mixers and amplifiers can produce harmonics which are multiples of the fundamental frequency. Recall that harmonics can cause interference to other amateur bands and other radio users.
3G3	23	Recall that a filter is a device that blocks some frequencies and passes others. Understand the effects of low-pass, bandpass and high-pass filters. Understand that a low-pass filter, a band-pass filter and a band stop (notch) filter can minimise the radiation of harmonics. Recall that RF power amplifiers can produce harmonics of the wanted signals and that suitable filtering is required to avoid harmonic radiation.

Ref	Q#	
3G4	23	Understand that too fast a rise and fall time of the transmitted RF envelope of a CW transmitter may cause excessive bandwidth (key clicks) and that this can be minimised by suitable filters in the keying stage. Recognise a diagrammatic representation of rise and fall time.
3G5	23	Recall the cause and effect of 'chirp' and identify suitable remedies.
3H		**Receiver concepts**
3H2	24	Understand the block diagrams of the crystal diode receiver, and direct conversion receiver. Understand the functions of the RF amplifier, demodulator (detector), and audio amplifier as used in an analogue receiver.
3H3	24	Recall that a receiver's ability to detect weak signals is known as its sensitivity. Recall that very strong signals can overload a receiver and cause distortion to the audio output.
3H4	24	Recall that a receiver's ability to reject frequencies outside the wanted signal bandwidth is known as its selectivity. Understand the limitations of tuned circuits in selecting wanted frequencies and the effect of the Q factor of tuned circuits. *See also Section 2H4.*
3I		**Superheterodyne concepts**
3I1	25	Understand the need for and advantages of the superheterodyne architecture. *Note: A diagram of the Single Conversion Superhet diagram is provided in section 4.*
3I2	25	Recall that the intermediate frequency is the sum of or difference between the RF and local oscillator frequencies, and is produced by a mixer.
3I3	25	Recall that a superheterodyne receiver uses a fixed IF stage to enable good selectivity and that mixing ahead of the IF enables multi-band reception. Understand that tuned circuits in RF and IF amplifiers select the wanted signal. Identify the tuned circuits in the circuit of an IF amplifier.
3K		**Demodulation**
3K1	26	Understand how a diode detector will recover the audio from amplitude modulated signals. Understand that to generate the audio from CW signals a Beat Frequency Oscillator (BFO) is used; for the recovery of single sideband audio a carrier insertion oscillator (CIO) and product detector are used and for the recovery of FM audio a discriminator is used. Identify the waveforms produced in a diode AM detector.

Ref	Q#	
3L		**Automatic gain control (AGC)**
3L1	26	Understand that the automatic gain control (AGC) of a receiver operates by sensing the strength of the received signals at the detector and adjusting the gain of the IF and sometimes the RF amplifiers to keep the audio output level fairly constant. Recall that the AGC signal can also drive a signal strength meter (S-meter).
3M		**SDR transmitters and receivers**
3M1	27	Recall that SDR software uses a mathematical function called a Fourier transform which sifts the composite signal into its constituent independent frequencies for processing. Recall that this can also be used to provide a spectrum or waterfall display. Recall that digital filters can be much more selective than analogue filters.
3M2	27	Recall the meaning of the time domain and the frequency domain. Understand how signals in the time domain may also be viewed in the frequency domain. Identify for some simple harmonic waves, the spectrum obtained using the Fourier transform. (*Waves composed of one and two Harmonics will be examined*).
3M3	27	Recall the different elements that make up the functions of an SDR (block diagram).

Section 4 – Feeders and antennas

4A		**Feeders**
4A1	28	Understand the equal and opposite currents flowing in a balanced feeder cause equal and opposite fields around the two conductors. Understand that these fields cancel out, but that nearby objects can cause an imbalance that makes the feeder radiate RF energy. Recall that a rectangular waveguide must have its larger dimension greater than λ/2 for the signal to travel.
4A2	28	Recall that twin feeder usually has lower loss than coaxial cable. Recall that loss is measured in dB. Understand the relationship between RF output power, feeder loss and power delivered to the antenna. Calculate the unknown quantity given the other two. *Feeder loss will be in multiples of 3dB and 10dB*.

Ref	Q#	
4A3	28	Recall that feeders have a characteristic impedance which depends upon the diameter and spacing of the conductors. Recall that this impedance determines the ratio of the RF RMS potential difference to the RF, RMS current in a correctly terminated feeder. Recall that for amateur use 50Ω coaxial feeder is normally used; that coaxial cable for TV and satellite receivers has a different impedance of 75Ω. Recall that balanced feeder is commonly available from 75Ω to 600Ω. Recall that correctly terminated means correctly connected with a resistive load equal to the cable characteristic impedance.
4B		**Baluns**
4B1	28	Recall the construction and use of choke type baluns.
4C		**Antenna concepts**
4C2	29	Understand the front-to-back ratio of an antenna. Understand the beam width of an antenna. Understand that radiation patterns exist in three dimensions.
4C3	29	Recall that an isotropic radiator is a theoretical antenna that radiates equally in all directions. Recall the Effective Isotropic Radiated Power (EIRP) is based on an isotropic antenna reference rather than a dipole and is expressed in dBi. Recall that a half-wave dipole has a gain, in its optimum direction, of 2.15dBi.
4C4	29	Recall that the angle at which the radio wave leaves the antenna is known as the angle of radiation and that longer distances normally requires a lower angle of radiation. Recall the effect of the ground on the angle of radiation.
4C5	29	Recall that the current flowing into an antenna is related to the feed point impedance and the potential difference of the applied signal. Recall that an antenna will only present the correct feed point impedance when fed with the frequency for which it is designed. Recall that a centre fed half-wave dipole has a feed point impedance of 73Ω in free space and that under practical conditions (e.g. due to ground proximity effects) this will be approximately 50Ω when used at its designed frequency.
4D		**Types of antenna**
4D1	30	Recall that a three-element Yagi has a half-wave driven element, a reflector that is slightly longer than the driven element and a director that is slightly shorter than the driven element. Recall that Yagi antennas may have more than one director.
4D2	30	Recall that an antenna trap is a parallel tuned circuit and understand how it enables a single antenna to be resonant and have an acceptable feed-point impedance on more than one frequency. Recall that this technique may be extended to multi-element antennas such as Yagis.

Ref	Q#	
4E		**Standing waves**
4E1	31	Understand that the signal reflected back down the feeder will combine with the waves travelling up the feeder from the transmitter leading to the formation of standing waves. Recall that both forward and reflected signals are subjected to feeder loss. Recall that the reflected signal will change the input impedance of the feeder so that it is no longer the characteristic impedance and the feeder will not then present the correct impedance to the transmitter.
4F		**Antenna matching units**
4F1	31	Recall that a transmitter is designed to transfer energy into a specific impedance. Understand that an Antenna Matching Unit (AMU) can change the impedance presented to the transmitter and that an AMU does not tune the feeder or the antenna to resonance. Understand that if the AMU is located at the transmitter, it will have no effect on the actual SWR on the feeder between the AMU and antenna.
4H		**Plugs and sockets**
4H1	31	Recall that in a correctly connected and terminated coaxial cable the RF field only exists within the cable and is not affected by objects outside the cable. *Note that correctly connected means screen and inner conductor continuity through any plug and socket.*

Section 5 – Propagation

5A		**Radio propagation: key concepts**
5A2	32	Understand the meaning of ground wave, tropospheric (space) wave, sky wave, skip distance and skip zone (dead zone).
5A3	32	Recall that the ground wave has a limited range due to absorption of energy in the ground and that the loss increases with increasing frequency.
5A4	32	Recall that electromagnetic radiation comprises both an electrical field and a magnetic field. Recall that the two fields are always at right angles to each other and that the direction of propagation is at right angles to both fields. Recall that it is the plane of polarisation of the electric field that defines the polarisation of the electromagnetic wave.

Ref	Q#	
5B		**Ionosphere**
5B1	33	Understand that the ionosphere comprises layers of ionised gases and that the ionisation is caused by solar emissions including ultra-violet radiation and charged solar particles. Recall the ionospheric layers (D, E, F1 and F2) and approximate heights.
5B2	33	Recall that the level of ionisation changes with the time of day, the time of year, and according to the, approximately, 11-year sunspot cycle. Understand that the sunspot number is an indicator of solar activity and that more sunspots give better HF propagation as a result of increased ionisation. Recall that the highest frequency that will be refracted over a given path is known as the Maximum Usable Frequency (MUF).
5B3	33	Recall that the F2 layer provides the furthest refractions for HF signals (about 4000km) and that the F layers combine at night. Recall that multiple hops permit worldwide propagation. Understand how fading occurs and its effect on the received signal. Recall that Short Path ionospheric propagation of HF signals is the most direct route around the earth. Recall that Long Path ionospheric propagation is where HF signals are received via the opposite route around the earth to the Short Path.
5B4	34	Recall that the D layer tends to absorb the lower radio frequencies during daylight hours and that it tends to disappear at night. Recall that the lowest frequency that can pass through the D-layer without significant absorption is the Lowest Usable Frequency (LUF). Understand that if the D-layer absorption (LUF) occurs at frequencies higher than the MUF then no ionospheric propagation can occur.
5B5	34	Recall that in addition to VHF, waves in the in the 24 MHz and 28 MHz upper HF band can also occasionally be significantly increased by refraction from highly ionised areas in the E layer (Sporadic E). Recall that the height of the E layer will support a single hop of up to about 2000km and that multi-hop propagation can occur.
5C		**VHF and above**
5C3	34	Recall that at VHF and above, multipath propagation can occur where signals are reflected off objects (such as a buildings or aircraft) and the reflected signal is received in addition to the direct, un-reflected, signal.

Ref	Q#	

Section 6 – Electro magnetic compatibility (EMC)

6A EMC concepts

6A1	35	Understand that all electronic equipment is capable of radiating and absorbing radio frequency energy. Recall that the basic principle of electromagnetic compatibility is that apparatus should be able to function satisfactorily in its electromagnetic environment and without causing undue electromagnetic disturbance to other apparatus in that environment.
6A2	35	Recall that the immunity of a device can often be improved by screening and filtering power, signal and control leads.
6A3	35	Understand that transmitters in domestic environments may give rise to RF fields stronger than the agreed limits. Understand that transmitters in domestic environments are not normal situations and special measures may have to be taken.
6A4	35	Understand that new electronic equipment should meet the British Standards Institute immunity requirements but that existing equipment and poorly installed equipment may not.

6B Sources of interference and their effects

6B1	36	Recall that speech transmissions, particularly AM and SSB may cause speech like sounds in analogue radio, audio systems and telephones. Recall that FM transmission is more likely to mute or reduce the volume of the wanted signals (audio or RF).
6B2	36	Recall non-radio sources of interference and their effects: • Arcing thermostats • Vehicle ignition systems • Electric Motors • Computers and peripherals • Switch mode power supplies • Plasma TVs • Very high bit rate Digital Subscriber Line (VDSL) equipment • LED lighting • Solar photovoltaic (PV) inverters Recall that this gives rise to various buzzing sounds on analogue radio receivers which can correlate with the nature and use of the interference source e.g. bursts of undesirable sounds when a thermostat opens or closes.
6B3	36	Recall that interference to Digital Audio Broadcasting (DAB) may cause loss of signal (muted audio) and to digital televisions may cause the picture to freeze, appear to pixelate; that is break up into larger squares, become jerky or disappear.

Ref	Q#	
6C		**Routes of entry**
6C1	36	Recall that direct pick-up in affected devices tends to be independent of the transmitted frequency.
6C2	36	Understand that some masthead and down-lead TV amplifiers are broadband, amplifying a wide range of frequencies, including amateur frequencies. Understand that this can result in overloading of the amplifier and/or the TV input.
6D		**Filtering and remedial measures**
6D1	37	Understand that filters can be fitted in the leads from the power supply to the transmitter to help minimise RF energy entering the mains wiring. Recall the use of ferrite ring filters for minimising unwanted RF on antenna down-leads and mains leads to affected equipment. Recall and understand the use of high-pass or low-pass filters to reduce the level of HF and VHF amateur transmissions into other electronic equipment. Understand the use of mains filters to reduce RF, electric motor and thermostat interference to TV, radio and audio systems.
6D2	37	Understand the meanings of common mode and differential mode currents and signals. Understand how a ferrite ring or choke can be used to attenuate common mode signals in twin wires and braid currents on coaxial cables.
6D3	37	Recall how to use a suitable general coverage receiver to check for spurious and harmonic emissions from the station.
6D4	37	Understand the use of a dummy load in fault finding. Recall that the resistor(s) used in a dummy load must be non-reactive and of a suitable power rating. Recall how to use a dummy load to check if interference is being caused by a radiated signal or leakage into the mains or other wiring.
6E		**Station design and antenna placement/general principles**
6E1	38	Recall how to interconnect the transmitter, microphone, power supply, SWR meter and band or low pass filters, using appropriate cables, to minimise EMC problems.
6E2	38	Recall what constitutes a good RF earth, its purpose and use.
6E3	38	Understand that siting a transmitting antenna close to mains wiring, TV or radio antennas and down-leads is a potential problem exacerbated by the use of a loft or indoor transmitting antenna

Ref	Q#	
6F		**Station design and antenna placement/mobile installations**
6F2	38	Recall that when routing RF cables and mobile radio DC power leads within vehicles they should not be routed in parallel with the vehicle wiring loom and they should not be run near electronic control units. Recall that radio frequency energy can cause interference to vehicle electronic circuits, including audio systems, navigation systems, remote locking, alarms and engine fuel management systems particularly when operating equipment with an RF output of 10W or more.
6F3	38	Understand that mobile antenna location can affect the radiation field strength within the vehicle; e.g. wing or boot mounted antennas are likely to produce higher exposures than roof mounted antennas.

Section 7 – Operating practices and procedures

7A		**Good operating practices and procedures**
7A3	39	Recall common international call sign prefixes; EI(Eire), F(France), I(Italy), JA(Japan), PA(Netherlands), VE(Canada), VK(Australia), W(USA), ZL(New Zealand).
7A4	39	Recall that there are awards available for achievements which include: working continents, countries, islands, prefixes, locator squares and that variations may include certain frequency bands or low power. Recall that amateur radio contests require the exchange of information such as signal report, serial number and location. Recall that contests often have sections for different bands, power levels and modes.
7B		**Band plans**
7B1	39	Recall that band plans are produced by the IARU. Recall that the band plans state that: • no SSB operation should take place in the 10MHz (30m) band • no contests shall be organised in the 5MHz (60m),10MHz (30m), 18MHz (17m) and 24MHz (12m), bands • transmissions on satellite frequencies should be avoided for terrestrial contacts. *Note.* *The 5MHz (60m) band is **NOT** available to Intermediate Licence holders.* *Questions on beacon frequencies will be limited to the 14MHz (20m) and 144MHz (2m) bands. Questions on satellite frequencies will be limited to the 144MHz (2m) band. A copy of the relevant Band Plans will be provided.* *The Band Plan supplied for examination purposes will be a typical plan and need not be one in current use. The Reference Booklet containing the examination plan is available on the RSGB website.*

Ref	Q#	
7E		**Codes and abbreviations**
7E1	40	Recall the meaning and the reason for use of the Q codes: QRM, QRN, QRO, QRP, QRT, QSB, QSL, QSO, QSY, QTH.
7F		**Digital interfaces**
7F2	40	Recall that several types of transmissions can be generated and received with the use of a personal computer and a suitable interface. Recall minimal distortion can be obtained by careful adjustments between the DAC interface and the transmitter. Recall other programs running on the PC that is handling the transmitter or receiver audio may cause interference e.g. warning beeps and alerts.
7G		**Satellites**
7G1	40	Recall that satellites orbit the Earth at heights above 250km, and understand that most amateur satellites are moving in relation to the Earth and will only be above the horizon at certain times.
7G2	40	Recall that the up-link and down-link frequencies are generally in different amateur bands and that details are published by amateur organisations. Recall that the transmitting station must be able to receive both the up-link and down-link signals.
7G3	40	Understand that amateur satellites can only be used when they are above the horizon at both the sending and receiving stations, and that the movement of the satellite will cause frequency variation, known as Doppler shift, on the received signal, which must be allowed for when selecting operating frequencies.
7G4	40	Understand that satellites have a very limited power supply, derived from solar panels, and that excessive up-link power may result in wasteful and unfair use of the satellite's power.
Section 8 – Safety		
8A		**Electricity**
8A1	41	Understand that large or high-voltage capacitors can store dangerous electric charges and must be discharged before working on equipment. Recall that large value resistors can be used to provide leakage paths for these stored charges.
8A4	42	Recall that equipment mains fuses may be of a special type, such as quick blow or slow blow to allow for an initial surge of current and that the specified type must be fitted. Understand that a fuse must be correctly rated for proper protection, and, in the absence of manufacturer's instructions, to select an appropriate fuse. *For mains: current = power/230 where 230 is the nominal mains voltage.*

Ref	Q#	
8A6	41	Understand that working on live equipment must only be done if it is not practicable to do otherwise and if the risks and appropriate precautions are fully understood.
8A8	42	Understand that vehicle batteries are a source of very high currents which can start a fire and that battery contents are corrosive. Understand that explosive hydrogen gas can be given off when charging batteries and that ample ventilation is required.
8B		**Using tools**
8B2	43	Understand that screwdrivers, drills, saws and files must be handled with care. Understand that fingers should always be behind the blade of hand tools.
8B3	43	Understand that any items being drilled, sawn or filed must be securely held in a vice or similar device to prevent them slipping or rotating.
8B4	43	Understand that any locking keys, and/or chuck keys, must be removed before using a power tool such as a drill to prevent the key being ejected at high speed.
8B5	43	Understand that using a centre punch will help prevent a drill bit slipping.
8B6	43	Understand the reasons why a bench-mounted pillar drill is safer than a hand-held drill.
8E		**Lightning**
8E1	41	Recall that limited protection of equipment against the build-up of static charge can be obtained from gas discharge arrestors, spark gaps and bleed resistors.

Section 9 – Measurements and construction

9A		**Measurements**
9A1	44	Recall the purpose of a multimeter and understand how to set the meter to the correct range and polarity before connecting to the circuit.
9A2	44	Understand that voltmeters have a high internal resistance so that they draw minimal current from the circuit under test. Understand that ammeters have a low internal resistance so that they minimise the voltage loss to the circuit under test. Understand that a voltmeter is always connected in parallel with a component or circuit being tested. Understand that an ammeter is always connected in series with a component or circuit being tested.
9A3	44	Understand the advantages and disadvantages of analogue and digital displays, and be able to read analogue and digital values.

Ref	Q#	
9A5	44	Understand the use of voltmeters and ammeters to determine the power applied to a circuit.
9B		**Decibels**
9B1	45	Recall that decibels are a logarithm of power ratio. Recall that a power gain of 3dB equates to doubling the power and 10dB equates to a power increase of times 10. Calculate the power gain or loss of various dB ratios based on 3 and 10dB and their multiples. This includes examples such as 25W is equivalent to 14dBW. Recall that dB gains and losses in a system can be added to find the total gain or loss in the system. Recall the meaning of: • dBW (comparison with 1W) • dBi (comparison with an isotropic radiator) and • dBd (comparison with a half wave dipole).
9C		**Components**
9C1	46	Recall the resistor colour code, colours 0 to 9 with gold as multiplier. Recall silver (10%) and gold (5%) as tolerance bands. Identify the value of a resistor between 1Ω and 9MΩ from the E12 series. Recall how to read both 4 band and 5 band resistors. Recall how to read components with a numeric marking of the format 4R7, 3k3 or for capacitors, 103. *Note: The resistor colour code will be provided and actual encoding or decoding of colours will be either 4 band or 5 band resistors. Candidates are not expected to know the values of the E12 series.*
9D		**Construction**
9D1	46	Recall that screening with thin metal sheet is effective in reducing unwanted radiation from equipment and/or between stages within equipment.
9E		**Soldering**
9E1	46	Understand that soldering is a method of joining metal wires and components using solder and a hot soldering iron.
9E2	46	Recall that solder is a low melting point alloy and that many solders contain a flux to help the solder to flow and to prevent a layer of oxide forming on the surfaces to be joined.
9E3	46	Recall that some metals are easier to solder than others.

Ref	Q#	
9E4	46	Understand that the tip of the soldering iron has to be cleaned to help remove any oxide and then tinned to prevent the oxide re-forming and to improve the conduction of heat to the joint. Recall the reason for tinning wires prior to soldering.