Mock Full Paper 2 Worked answers

You should attempt all the questions in the mock paper first, before looking at the worked answers.

1   D

There are specific requirements for operating in the 5MHz bands in note (g) to Schedule 1 of the licence. Sub-clause (vii) refers to operating in a net and sub-sub-clause (a) shows option D is correct. Careful reading of the rest of the note shows that the other requirements don't quite fit the question asked.

The 15 minute rule, for example, applies when operation has been 'other than in speech mode' and the question did not say that was the case. As a matter of normal examination protocol you must **not** assume things that are not actually stated in the question.

2   A

This is simply answered by looking at licence clause 17(1)(dd).

3   D

Licence clause 14(2) says that the origin of the message and the origin of the re-transmission must be clear if you choose to re-transmit the message originator's callsign.

4   C

The question deliberately invokes the licence; clause 7(3) says you must not cause Undue Interference to any wireless telegraphy. The WT Act uses that term to cover any form of radio communication.

Obviously it is socially responsible to not cause any interference to any equipment but this is a question about what the licence says, which is limited to devices covered by the WT Act.

5   D

This is another example where care is needed in reading the question and understanding the licence. At Full level there are no specific licence requirements on the link. All that is required is the same licence compliance as for any other amateur transmission.

The link must be secure against use by others but not encrypted. Note (g) to the licence say the link <u>should</u> by above 30MHz, the question said <u>must</u>. As a matter of law and licence compliance such distinctions do matter. The 500mW pep e.r.p applies only to Foundation and Intermediate licensees. It is a standard presumption that questions relate to the level of licence being examined unless stated otherwise.

6 A

The CEPT arrangement is that you are recognised as an amateur in exactly the same way as indigenous amateurs. You must comply with the local licence conditions.

The requirement to comply with the local conditions means that the terms of your UK licence are not relevant; you are not in the UK. In international waters it is subtly different; you are still governed by your UK licence with the additional requirement that you can only use bands that are also allocated to amateurs in the ITU Region concerned.

7 C

Note (f) to the licence schedule answers this question, sub clauses (iv) and (v).

There is no requirement to remember the licence terms but you should know your way round it and where to find the answers.

At Foundation and Intermediate levels there are licence requirements that you need to know in everyday use. At Full level there is an assumption that you will look up the less used terms if your intended activity requires it. A copy is provided in the exam for that purpose.

8 A

Careful inspection of the circuit will show that the potential dividers 1kΩ+3kΩ and 6kΩ+18kΩ means that there is no voltage across the 5Ω resistor and thus no current and no power. A change in the battery voltage will have no effect on the 5kΩ resistor.

If the potential dividers did not give the same voltage at each end of the 5kΩ resistor then normal series and parallel calculation methods would not apply. The circuit is known as a bridge configuration. Handling such circuits is not within the syllabus. If you see such a circuit the first thing to do is check the division ratio of each potential divider. What are the voltages at each end of the horizontal component if you pretend it isn't there?

9 B

The key point to note is that for capacitors in series the charge on each capacitor is the same. They have same charging current for the same time. Then, remembering C=Q/V from the formula sheet gives V = Q/C so a smaller capacitor will have a higher voltage for the same charge; that is the air spaced one with the lower dielectric permittivity.

10 A

The back EMF will oppose both the rise and the fall of current in the inductor. On closing the switch the current will rise slowly and is eventually limited by the internal resistance of the inductor and, if relevant, the resistance of the wires and internal resistance of the battery. The back EMF in the inductor will initially be almost 6V, falling as the rate of rise of current falls.

On switch off the circuit is broken instantly. In theory that will cause an infinite back EMF in the inductor. Sparking at the contacts means the fall of current is rapid but not instantaneous. In this instance some of the energy in the magnetic field is used in striking the neon. It flashes only when the switch is opened.

The neon symbol isn't in the syllabus, which is why you are told what that symbol means.

11 A

After one time constant the voltage on the capacitor will have risen to about 2/3 of the final voltage so the circuit will operate after one time constant CR. C = t/R =10/68k = 147µF. Pick 150µF. *Such capacitors have a tolerance on their value of ± 10 or 20 % so the 'error' is insignificant.*

12 C

The reactance of a capacitor falls as the frequency rises.

If you are not sure, the formula for XC is on the formula sheet.

13 C

Sampling at 9000 times a second means that the Nyquist frequency is 4500Hz. If there is a signal present 100Hz above that then it will result in an alias 100Hz below. A signal at 4600Hz will be interpreted as one of 4400Hz.

An alias at 3000Hz is 1500Hz below the Nyquist frequency so the actual signal was at 4500+1500=6000Hz.

Sampling a signal of exactly 4500Hz exactly 9000 times a second will just fail to capture the signal. If the first sample point was at a zero point then every other sample will be zero. It is necessary to sample very slightly faster so that a sample does capture the peak.

14 A

The voltage and current are transformed by the turns ratio, impedances are transformed as the <u>square</u> of the turns ratio.

15 C

The Q-factor is set by the ratio of the 3dB bandwidth and centre frequency - see formula sheet.

From the graph 3dB down looks to be a bandwidth of around 2.8kHz which gives a Q-factor of Q =10700/2.8 = 3821. Given the estimate from the graph probably the best we can say is between 3500 and 4000. There is only one answer that is in that range so C it is.

A common error is to overlook that the bandwidth is in kHz and the centre frequency is in MHz.

Take care!

16 C

The FET normally has its gate-channel junction reverse biased so the depletion layer widens as the reverse bias increases, thereby narrowing the channel. That is termed depletion mode.

Values do vary but a few volts of reverse bias is typical. With the source at 2V the gate will be less than that so 0.5V is an answer. All the other options are zero or positive bias and thus wrong.

The gate-channel junction behaves like a diode so has a potential barrier of about 0.6V before the junction becomes forward biased and conducts. That should not be allowed happen but it is possible to utilise some of the 0.6V headroom before conduction to control the source – drain (electron) current. That is known as the enhancement mode. It is not common.

Insulated gate FETs still rely on the electric field to control the channel current but, having a very thin insulated layer between the gate and channel dramatically increases the input impedance into the MΩ range. That is reduced at RF by input capacitance.

17 C

This is a 'know it' question. The actual range is quite wide and depends on circuit values and currents but 1kΩ is a middle answer.

Common base is around 50Ω and emitter follower many kΩ or higher.

18 A

Read this question carefully! The key words are 'steady output voltage'. Transformers, rectifiers and reservoir are necessary in a (linear) PSU but the output voltage will vary with changes in load current. The Zener reference diode and a series pass transistor are required to provide voltage regulation.

19 B

A balanced modulator is used for SSB. Its output is two sidebands with no (at least a very well suppressed) carrier. The unwanted sideband is filtered out by a sideband filter.

20 D

Options A and B will help reduce frequency drift but are hardly the best option. Option C is easily the worst. All components will have some temperature related changes but having an equal mix will minimise the overall effect even if the temperature does change.

21 A

The formula is in the provided sheet but this can be worked out with a little thought. The two inputs to the phase comparator must be the same frequency if their relative phases are to be compared. The reference input is 6.80MHz divided by 6000. The VFO output to the comparator is divided by 9000. So its frequency before division must be 9000/6000 times the reference oscillator. 6.80 × 9/6 or 6.8 × 1.5, giving 10.2MHz.

22 B

You don't know the multiplication factor or which answer is correct. The quick way is to divide the operating frequency by each of the crystal frequencies looking for an integer result.

If there are other answers with an integer result remember that having 3 stages of multiplication can only result in certain numbers. In this case the multiplication is 27 as 3×3×3. An overall multiplication by, say, 26 is not realistic. It does factorise as 2×13 but a 13th harmonic is nowhere near strong enough to be usable. You should be looking for exact integers; an answer of 8.9 might look like 3×3 = 9 but, if necessary, check all four answers; don't pick the first one that seems close.

23 B

We are told the modulator and sideband filter are good but the PA is non-linear. We are looking for intermodulation products of 144.6008 MHz and 144.60135 MHz.

Try 2×144.6008 – 144.60135 = 144.60025 MHz. No!

2×144.60135 – 144.6008 = 144.6019 MHz Yes!

Those of you more adept at maths may notice that the 5th decimal place (the 10s of Hz of audio) in all the answers is zero in all the answers. The only way that can occur is if the 1350 Hz (or 144.60135 MHz) frequency is multiplied by 2. That might trigger you to try that option first.

The other point is that the calculations can equally be done on the audio frequencies, as in 2×1350 – 800 = 1900 and then add the 144.6 MHz to get 144.6019.

Which of these options you choose is an individual choice. You may also choose to leave this question to later in the exam when you know how much time you have remaining to tackle a reasonable but more laborious and time consuming question.

24 A

A single low pass filter at 30 MHz won't deal with the harmonics of the lower bands. Some HF transmitters have a selection low pass filters but this question deliberately noted that modulation was done in the 7 MHz band which should also be filtered out when on bands above 7 MHz. Consequently the choice is for band pass filters.

25 C

Dynamic range, given in dB. Knowing the definition of terms is essential, not just because they are examinable but because their exact meaning is important in other questions.

26 B

The image is twice the (first) IF removed from the wanted frequency and on 'the other side' of the local oscillator. The fact that it was a double superhet was just a red herring.

27 C

Feeder loss simply buries the wanted signal further into the noise and the loss increases with increasing frequency. To achieve the best sensitivity, ie best signal to noise ratio, the preamp should be at the antenna. The S/N improvement is equal to the feeder loss (all other things being equal). *It is also important that the preamp has the lowest noise figure itself and better than the front end of the main receiver.*

28 D

A know it question. The SSB signal in the IF is mixed down to audio by the IF and CIO being mixed together in a mixer termed a product detector to reflect its particular usage. *The same oscillator can be offset by some 600Hz to beat with a Morse (CW) signal in the IF, when it is called a beat frequency oscillator.*

29 D

In some respects this is a choice of the *best* answer.

A is simply wrong; polarisation diversity will give some protection against ionospheric fading but that equally applies to analogue receivers.

An SDR receiver is capable of extracting both sidebands simultaneously given suitable software but that is not the reason for having two signals with a 90° phase difference.
Given adequate dynamic range an SDR receiver can perform the AGC function digitally but again that is not a reason for the 90° signals.

The correct answer is that in order to have a choice of demodulation modes in software it is necessary to know both the amplitude and phase of the received signal as it is varied by the modulation.

30 C

In effect the 28MHz receiver is being used as if it was the first IF of the 433 MHz receiving system. Two options, 433 MHz ± 28 MHz; 405 MHz or 461 MHz.

31 B

The λ/4 sleeve balun works rather like a quarter wave coax impedance converter but acting on the main coax outer. As such the dielectric is the plastic sheath of the coax and its permittivity will determine the velocity factor and thus the length of the λ/4 sleeve.

32 C

At 7.1 MHz the free space wavelength is 300/7.1 = 42.253m. That figure needs to be halved and then reduced to 95% of that length to account for 'end effect' giving 20.07m - to the nearest cm. *In reality the surroundings and ground will have an effect, cut long and trim – carefully!*

33 A

A good way to picture this is to assume the antenna has fallen off and all the signal is reflected. The signal returning to the transmitter has transited the feeder twice so will suffer twice the feeder loss. Return loss (RL) is defined as incident power/reflected power. The RL at the transmitter will be the actual RL of the antenna plus twice the feeder loss.

In this case we know the RL at the transmitter
so the RL at the antenna will be 25 – 2×2.5 = 20dB.

34 B

The antenna matching unit (AMU) effectively cancels out any reactance presented by the feeder (or antenna if at the antenna end of the main feeder) and also brings the resistive portion of the load impedance to 50Ω.

It does not change the antenna feedpoint impedance, that is purely a function of the frequency and the dimensions, construction and location of the antenna. If the AMU is at the transmitter end of the feeder then there will still be standing waves on the feeder. Locating the AMU at the antenna avoids that but introduces control and environmental challenges.

35 C

The Power Flux Density (W/m^2) reduces as the inverse square of the distance; Field strength (V/m) is an inverse linear relationship.
Note power being the square of the voltage applies to EM fields in the same way as it applies to power and voltage in a resistor.

36 B

A solar flare emits vast quantities of charged particles which results in a dramatic increase in ionisation. The E and F layers may become more refractive but the D layer becomes much more absorptive and ionospheric propagation may well be wiped out for a while.

37 C

The aurora is caused by charged solar particles directed towards the poles of the Earth's magnetic field. The resulting ionisation appears as coloured 'curtains' in polar regions. These move or flutter randomly and reflect radio waves. Demodulation produces an audio flutter as well as the wanted signal.

38 B

If the coax screening is interrupted then the coax will act as an antenna adding the signal picked up on the coax to the wanted signal on the coax inner conductor.

39 C

As a homemade device, i.e. not commercial, the only requirement is to comply with the terms of the amateur licence. Commercial equipment must also comply with IR (Interface requirement) 2028. *IR2027 is for CB equipment.*

40 A

Blocking is a continuous interruption to an adversely affected receiver which implies an FM modulation.

41 C

EMC problems usually involve several potential factors and the diagnostic task is often a matter of elimination. In this scenario the pickup could be on either (or both) sets of speaker leads or the mains lead/house mains wiring. It is also possible that there is a direct copper route from the transmitter along the mains supply wiring to both houses.

If the pickup is on the speaker leads then it is likely the RF is being rectified in a diode or transistor junction and amplified by the audio amplifier. Depending on the exact route of ingress and whether or not one of each speaker lead is permanently connected to the common (0V) rail of the audio amplifier, swapping the two pairs of speakers may or may not make much difference. Eliminating conducted interference by transmitting into a dummy load is an easy first step.

Disconnecting both sets of speaker leads and using headphones if there is a suitable socket may eliminate that route. Ferrite rings on the speaker leads may then be a solution. So might rings on the mains lead if that is picking up the RF. If the first test shown it is conducted interference through the mains wiring then the problem needs to be sorted at the transmitter, the complainant might not be the only person affected and it is good EMC housekeeping anyway.

42 D

DAB broadcasts in the UK are in the frequency band from 174 to 230MHz.
174/28 is 6.2. 230/28 is 8.2 so the only available answer is the 7th harmonic.

Knowing some frequencies is a syllabus requirement, they are not given in the Reference Booklet.

43 B

The TV broadcast band is 470 MHz to 694MHz at the time of writing (Feb 2021). A High pass filter set just below 470MHz will be suitable.

The syllabus gives the TV broadcast band as 470 – 790 MHz which was correct at the time it was published. Digital TV has allowed the TV band to be reduced and the band progressively used for other purposes such as 5G mobile phones.

44 B

The formula, from the booklet is $\mathrm{E} = \frac{7\sqrt{400}}{20} = 7\ \mathrm{V/m}$

45 D

Both A and B will have the feeder run diagonally under the antenna resulting in substantial pickup on the coax outer or as a common mode signal on twin feeder. Real risk of EMC problems. Burying twin feeder will result in losses and unbalance, also ill advised. D is by far the better option.

46 A

FCS1362:2010 'UK CODE OF PRACTICE for the installation of mobile radio and related ancillary equipment in land based vehicles' is the recognised standard for fitting radio equipment in vehicles.

It does say that specific instructions by the vehicle manufacturer take precedence but not fitting amateur equipment in the advised manner may have insurance implications and your insurer may require to be informed of such installation.

47 D

In the first instance you don't know if your transmission is the problem so checking the times with your Log is the first action. It also lets the complainant know you keep one.

If it looks like it was you, you will know from your Log what you were doing so you can replicate the problem with the complainant's agreement and then set about diagnosing the actual cause.

48 C

If you are a wanted contact with a pileup such that you cannot make out callsigns from the cacophony of callers it is useful to say you are listening a few kHz up (or down) the band. Hopefully that will spread the callers out enough for you to note a few callsigns and then go back to them.

49 D

This requires a careful look at the 5 MHz band plan which is in the Reference Booklet.
Note 4 says 'Contacts within the UK should avoid the WRC-15 band (5351.5 - 5366.5 kHz) if possible.'

The cited band is 5362 kHz to 5374.5 kHz. If you avoid the WRC-15 band 5351.5 kHz to 5366.5 kHz (not all of which is in the UK licence) then the remaining portion recommended for inter-UK contacts is 5366.5 kHz to 5374.5 kHz.

50 B

Option A is wrong, there is no requirement for each premises to provide its own earth rod.

Option B is a correct statement.

Option C is wrong on two counts. There is no company Earth but the company Neutral is earthed at regular intervals along the street. The house safety earth is bonded to it at the Main Earth Terminal (NET).

Option D is wrong, as in C it is the company Neutral which is earthed.

51 C

The International Commission on Non-Ionising Radiation Protection (ICNIRP) advised on safe limits for human exposure to electromagnetic radiation. Public Health England (for the whole UK) simply advise the ICNIRP limits.

The National Institute for Health Protection (NIHP) will replace PHE and the other three UK nation bodies, sometime in the spring of 20121.

52 C

Checking the adequacy and safety of the mains supply is an essential pre-requisite without which the event cannot go ahead as initially planned. The other factors are sensible matters but are either not checkable in advance or merely desirable if achievable.

53 A

The key features of a risk assessment are the identification of risks, how likely they are to happen and what the likely effect is if they do. The other options in this question relate to things you might do or have available should the assessment indicate it is sensible.

It may be helpful to assign numbers to severity and probability. The product of those numbers then gives a guide as to how much attention is paid to that particular risk. Will a first aider do or should more extensive facilities such as having St Johns ambulance in attendance be required. In all cases adequate insurance cover is needed and may be a condition of running the event or being granted access to hired or borrowed premises.

54 C

A voltmeter needs a high value series resistor, called a multiplier resistor, to limit the current such that the meter indicates a full scale deflection at the peak voltage of the chosen range.

Including the 0.1Ω resistor might prove both exciting and expensive if it is in the circuit at all.

55 C

Some care is needed to ensure you understand the measurement procedure being performed. The first part is to establish what 10W pep looks like on an oscilloscope. The dummy load and RF voltmeter is a much more accurate way of measuring power and a steady CW signal (key down) will give a stable measurable voltage with the power calculated as V^2/R.

The SSB signal is now displayed such that the peaks do not exceed to 10W pep level on the oscilloscope,

Re-arranging V^2/R gives $V = \sqrt{(P \times R)} = \sqrt{(10 \times 50)} = 22.36$ V. 22V is as close as realistically achievable.

56 C

Setting a lower voltage per division on the screen graticule means a given voltage will produce a larger trace.

57 B

The catch in this question is that the high impedance micro-voltmeter is measuring the source EMF since no load is attached. When the dummy load is attached the voltage across the load will drop to 5µV, which is the condition under which the power dissipated must be calculated.

The power is $V^2/R = (5 \times 10^{-6} \times 5 \times 10^{-6}) / 50 = 5 \times 10^{-13}$ W

1×10^{-13} W is -130 dBW we want 5 times that, 7dB higher at -123 dBW

The question asks for the values in dBm, power related to 1mW which is 30 dB lower than 1 watt. Subtracting 30 from the dBW figure gives -93 dBm.

58

The error in ppm applies equally to the oscillator error or the error at 144 MHz.
1 ppm is a 1 Hz error in a 1 MHz signal so the actual error, which must be taken as worst case where all the errors are in the same direction is 0.3 + 0.5 ppm = 0.8 ppm.

That gives an error of 0.8 × 144 = 115.2 Hz.

Not for the exam but the 'more likely' error is often taken as the rms sum of the individual errors.

That is $error = \sqrt{0.5^2 + 0.3^2}$ *= 0.58 ppm and 84 Hz.*

Relying on that close to the band edge means there is still a chance part of your transmission is outside the band and a breach of the licence.