FEEDBACK: PHYS30101 JANUARY 2017

General Comments

Overall the examination was well done and practically every student demonstrated an understanding of quantum mechanics at a level appropriate to a third year undergraduate. The performance was similar on all four questions. But (as usual) many marks were lost with silly slips in mathematics and careless errors - this is soul destroying when you are marking because you can see the understanding is there, but you can't award full marks where there are mistakes. Almost every script had some issue like this.

Practically everyone chose to do Questions 2 and 3, while 4 was unpopular - but there was very little difference in the average mark on each.

This year, for the first time in a while, I had no issues with not being able to read poor handwriting.

Exam technique

Firstly, an issue that persists from year to year. Where there are a number of marks allocated for more qualitative answers, full marks are likely to require a commensurate number of substantive points to be made. One-sentence answers to questions with several marks are not going to score highly. Moreover, in some cases, large volumes of text that didnt make sufficient substantive remarks will also not attract high marks.

Question 1

Overall not badly done.

In Part (a), some people suffered by not being very precise with their language, some gave examples where the question was really getting at general geometric definitions and some people missed that these systems need to be confined to small enough dimensions for quantum effects to be apparent.

Part (b) was fine in most cases, although there was a wide mark distribution which depended on the extent of the detail that was given.

Most people got the first bit of Part (c); fewer were able to how the expectation was zero. Nothing very clever was needed, just sandwich the expression for the operator in the ladder form between eigenstates of J_z with quantum number M, operate to the right with the ladders and you end up with two direct products of orthogonal states i.e. zero.

Part (d) is asking about $two\ state$ rather than $two\ particle$ systems - but many answers went unnecessarily into entanglement, then drifted off into irrelevant discussions of computing or cryptography. A $physical$ process suggests changing a field or a voltage, rather than describing a general logic gate. Full answers where spin halfwas used should mention the magnet field direction when one was used for processing. Some people missed connecting two states to the ones and zeros of binary numbers.

Part (e) was generally done very well and I was especially pleased to see almost universal correct answers for the last part. The only slip was to introduce an ω without defining it. Some missed the g factor in the magnetic moment for an electron.

Question 2

Most of this question was done well.

In Part (a), the main issue was not giving enough relevant points to get full marks. Several people gave lots of details of a wave hitting a square barrier, continuity relations and definitions of transmission coefficients. This is only partially relevant since the question was really looking for how the formula arises from thinking about a smooth potential barrier as a series of narrow square barriers.

For Part (b), some people confused the definition of the classical turning points as when $V(x)$ was zero rather than when it was equal to E. A few incorrectly assumed that $a = 0$. On the whole, most of those who got this far found the integral relatively straight forward - although, many suffered from careless slips in mathematics as far as full marks were concerned. Those fudging there working to get the answer given are not going to fool the examiner!

For Part (c) the answers were all mostly correct, but needed more points for full marks - a discussion of resonance, interfering waves, matching to quasi-bound levels and an increasing resonance width with energy were all relevant here.

Question 3

Surprisingly, the description of magic numbers were not on the whole very good. The point that fermions fill levels due to the Pauli principle was a simple and necessary point that most missed. After that filling of levels to give full shells was fine; some even talked about energy gaps. Most came up with an example and an associated property.

For Part (b), the commonest errors were to either to give totally the wrong formula for the eigenvalues (usually giving a cubic box rather than a 3D oscillator) or missing that the integers in the expression n_x etc start at zero for an oscillator, rather than unity. The angular momentum required a bit of free thinking; a minority of people realised than equating the vibrational degeneracy (i.e. without the times two spin factor) with the degeneracy $2\ell+1$ would allow them to deduce ℓ. A few got the two ℓ that would match the degeneracy of the third level, but not many.

I had expected the perturbation theory to cause more trouble than it did. On the whole, answers indicated that handling the integral was fairly straight forward. There was a general confusion between the *ground state energy* and the *shift in energy*, not the same thing since the unperturbed ground state is at an energy of $\hbar\omega/2$.

Question 4

This turned out to be a question where you could either do it or you can't. But most people where able to successfully navigate through Parts (a) to (c) with little worries, other than minor slips here and there. In the final bit of Part (c), marks were lost for not answering all the question. You did need to explicitly operate several times until you got a result of zero to prove how many states there were. Many people gave the magnetic quantum number rather than that for the total spin.

Again, I had thought that Part (d) might be trickier than it turned out. But I think most people who got this far remembered my advice that if the operator was a scalar product, follow the prescription from LS coupling.